Behaviours and Attitudes in the Management of Nonpoint Source Pollution: Ping River Basin, Thailand

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In memory of my father

DECLARATION

I hereby declare that this thesis is my own composition, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or professional qualification except as specified.

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ABSTRACT

Agricultural nonpoint source pollution is recognised as a major cause of water pollution. The characteristics of nonpoint source pollution suggest that an efficient approach should focus on a source control and hence land-use management. Recently, the concept of Payments for Ecosystem Services (PES) has been advanced as an efficient market-based approach to protect in-stream water quality, while simultaneously supporting agriculture. Farmers can be rewarded for the adoption of certain 'Best Management Practices' (BMPs) in farming systems. But little is known about the adoption of BMPs in the context of Thai agriculture.

This thesis examines the adoption of twelve BMPs on citrus farms in the Ping river basin in northern Thailand. In the context of potential PES development, three studies were undertaken using frameworks from economics and psychology. The first study used a bottom-up engineering approach to estimate economic costs of twelve BMPs at the farm-scale. The total annualised costs, including installation, maintenance, and land opportunity costs of each BMP were compared. The results indicated that land opportunity cost was the largest proportion of total costs. These estimates provided a basis for discussion on how the farmers' perception of cost may influence their stated adoption intention.

The second study used the Theory of Planned Behaviour (TPB), to investigate farmers' intentions on adoption of twelve BMPs. A survey of 218 citrus farmers was undertaken in the application. Descriptive statistics and frequency of BMP selection were presented. The results showed that soil analysis was the most preferred BMP. A graphical analysis of other preferred measures suggested that these were not always consistent with the known cost information derived (above) and thus farmers' perceived costs might not be the most important factor influencing adoption decisions.

Further analysis based on TPB investigated other factors thought to be significant in farmers' decision-making. Other potential external and psychological factors influencing adoption were investigated using a multinomial logistic model. The results indicated that the probability of adopting BMPs was associated with other psychological factors and external factors, rather than perceived costs. The significant psychological factors were farmers' attitudes towards consumers and perception about farm returns, while the significant external factors were, for example, access to information and contribution of family labour to farm workload.

The third study was based on the application of Q-Methodology, and aimed to obtain a deeper understanding of farmers' perception towards BMPs. Seventy two participants were purposively selected from the 218 TPB observations. The results revealed four distinctive farmer groups holding different perceptions towards BMPs. The four groups were conservationist, traditionalist, disinterested, and risk-averse. These provided a specific segmentation to guide policy towards influencing attitudes and behaviours. The results suggested that farmers were not motivated solely by a profit maximisation goal.

Overall, key findings from these three studies revealed some fundamental requirements for developing a water-related PES programme. These were: i) factors affecting eligibility to participate; ii) factors affecting desire to participate; and iii) factors affecting ability to participate. This information provided the basis for a set of recommendations addressing the development of the water-related PES programme in the Ping river basin.

ABBREVIATIONS

BAAC	Bank of Agriculture and Agricultural Cooperatives
BIBOR	Bangkok interbank offered rate
BMPs	Best Management Practices
BOD	Biochemical oxygen demand
BPP	Beneficiary pays principle
BT	Benefit transfer
CAC	Command and control approach
CBA	Cost Benefit Analysis
CEA	Cost Effectiveness Analysis
CPR	Common pool resource
Defra	Department for Environment, Food and Rural Affairs
DOAE	Department of Agricultural Extension
FAO	The Food and Agriculture Organisation of the United Nations
GDP	Gross domestic product
GBP	Pound sterling
IIED	International Institute for Environment and Development
MBIs	Market-based instruments
MC	Marginal cost
MFA	Material Flow Analysis
MSC	Marginal social cost
N	Nitrogen
NEB	National Environmental Board
NGO	Non-governmental organisation
OAE	Office of Agricultural Economics
OECD	Organisation for Economic Cooperation and Development
ONEP	Office of Natural Resources and Environmental Policy and Planning
P	Phosphorous
PCD	Pollution Control Department
PES	Payment for ecosystem services
PPP	Polluter pays principle
PWS	Payment for watershed services
RID	Royal Irrigation Department
SA	Sensitivity Analysis

SE	Standard error
TACT	Target, Action, Context and Time
TAOs	Tambon (sub-district) Administrative Organisations
TDS	Total dissolved solid
TEV	Total economic value
THB	Thai Baht
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
US EPA	United State Environmental Protection Agency
VIF	Variance inflation factor
WTA	Willingness to accept
WTP	Willingness to pay

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

1.1 Background of the Study

1.1.1 Overview of water pollution problems in Thailand

A decade of economic expansion in Thailand has changed the country from being one of the most resource-abundant countries to being one of the most resource-constrained. A variety of environmental problems are increasing pressures on natural resources. As a result, the Pollution Control Department (PCD) was established in 1992 under the Royal Decree on Organisational Division of Pollution Control Department, Ministry of Science, Technology and Environment B.E. 2535 (1992) (Enhancement and Conservation of the National Environment Quality Act B.E. 1992). PCD's mission is to protect human health, and to safeguard the natural environment upon which life depends. The Enhancement and Conservation of the National Environment Quality Act B.E. 1992 is the cornerstone of environmental protection in Thailand. The World Bank (2000) revealed severe cases of water quality degradation. A report by the World Bank in 2000 showed that 37% of surface water bodies in Thailand were classified as low quality. The Bank estimated that water and air pollution costs amounted to between 1.6% and 2.6% of Thailand's GDP (The World Bank 2004). Accordingly, the government has been heavily investing on water pollution abatement and control, and more than 40% of environmental budget have been spent to water pollution management (PCD 2005).

The major sources of water pollution in Thailand are domestic sewage, industrial effluents and agricultural runoff. Agricultural activity is the third largest source of water pollution, behind urban pollution and industry (FAO 2006). PCD (2005) has identified three main agricultural activities generating nonpoint source pollution to watercourses. These are livestock, coastal aquaculture, and plantations. To protect water bodies from pollutants, the government has established the ambient water quality standards mandated by the Enhancement and Conservation of the National Environment Quality Act B.E. (1992). Surface water quality standards are divided into five classes according to the major beneficial uses (The Royal Government Gazette 1994) (Table 1-1).

Table 1-1: Surface water quality standard

Classification	Objectives/ Conditions and beneficial use
Class I	Extra clean water used for conservation purposes
Class II	Very clean water used for: - Consumption which requires ordinary water treatment process before use - Aquatic organism of conservation - Fisheries - Recreation
Class III	Medium clean water used for: - Consumption, but passing through an ordinary treatment process before using - Agriculture
Class IV	Fairly clean water used for: - Consumption, but requires special water treatment process before using - Industry
Class V	The sources which are not classified in the above mentioned classes and can be used only for navigation

Source: The Royal Government Gazette (1994)

Influenced by the polluter pays principle (PPP), the government has put in place policies, plans, and water quality standards in an effort to combat water pollution. The emergence of pollution management policies in Thailand has increased in response to environmental conditionality linked to low interest loans from interested development agencies. The Enhancement and Conservation of the National Environment Quality Act B.E. (1992) applies laws and regulations for utilising environmental technologies, and mainly focuses on point source pollution control (Akihisa 2008).

Concern over nonpoint source pollution was publicly aired in the late 1990s (Tonmanee and Kanchanakool 1999). Current measures to manage nonpoint source pollution from agricultural sectors are effluent charges, an environment fund[1], subsidies, and a certification scheme (Table 1-2). Recently, PCD is considering the role of Best Management Practices (BMPs) as tools to control agricultural nonpoint source pollution at the watershed level (Water Quality Management Bureau 2006). PCD (2006) conducted a study investigating threats to water quality presented by farming activities in Thailand with a particular reference to surface water[2].

[1] The environmental fund was established under the Enhancement and Conservation of National Environmental Quality Act of 1992. It functions as a financial measure supporting grants and loans to environmental polluters. Major sources of funding are from state governments through the fuel oil fund, and international loans.

[2] The threats to water quality are evaluated by the significance of planted area, and application rate of chemicals.

Table 1-2: Experience with economic incentive measures in Thailand

Measure	Wastewater source		
	Community	Industry	Agricultural sector
Taxes, charge/ fees			
Product charge/ tax	/		
Tax/ fee exemption		/	
Effluent charge	/	/	/
Financial support			
Environment fund	/	/	/
Subsidies	/		/
Certification/ labelling	/	/	/
Public disclosure	/	/	

Source: Thomas (2006)

The study revealed six farming activities, which contribute to potential pollution hazards. These are maize, paddy rice, para rubber, citrus, cattle, and Nile tilapia. Table 1-3 illustrates the planted area of four crops that have a significant level of pollution hazard. Though the production of citrus is small scale, the severity of pollutant generates (i.e. high chemical applications) calls for urgent action for controlling pollutant emission.

Table 1-3: Planted area of crops with significant level of hazard pollution

Unit: 1,000 rai*

Plantation	Year							
	1998	1999	2000	2001	2002	2003	2004	2005
Citrus	322	343	348	365	410	446	466	479
Paddy rice	62,698	64,444	66,492	66,272	66,440	66,404	44,565	67,677
Maize	9,008	7,719	7,802	7,685	7,317	6,943	7,040	6,626
Para rubber	11,008	11,444	11,637	12,131	12,425	12,612	12,946	13,610

Source: OAE (2007)
Note: *rai is a land measurement unit in Thailand; 1 rai = 0.16ha

Accordingly, this thesis focuses on the pollution from citrus cultivation, and the promotion of plans to address water quality issues. The next section gives an overview of citrus production in the Ping river basin, a river basin of high economic significance where farmers are facing increasing competition from alternative water uses. This is followed by a review of the international view on citrus BMPs, and the basis used to select the BMPs evaluated in this thesis.

1.1.2 Citrus production in the Ping River Basin

The Ping river basin is the major watershed in northern Thailand (Figure 1-1; left). The basin is strategically important in terms of its upstream location, population density, economic integration, and as a cultural centre (Thomas 2006). The headwaters of the Ping river are in Chiang Dao district, Chiang Mai province, and it stretches to Nakorn Sawan province in the central area of Thailand. The Ping river basin covers an area of 33,898 km^2. It is divided into upper and lower portions at the Bhumibol Dam in Tak province. The upper Ping contains 15 sub-basins, while the lower portion comprises eight sub-basins. According to the surface water quality standard, the Ping river is classified as class III (PCD 2005). The Ping river basin is one of the four upper tributary basins forming the Chao Phraya river system, the most important river basin in Thailand. Functioning as the upstream of the Chao Phraya river basin, the Ping river is viewed as an area to be protected from any activity that would threaten water consumption downstream.

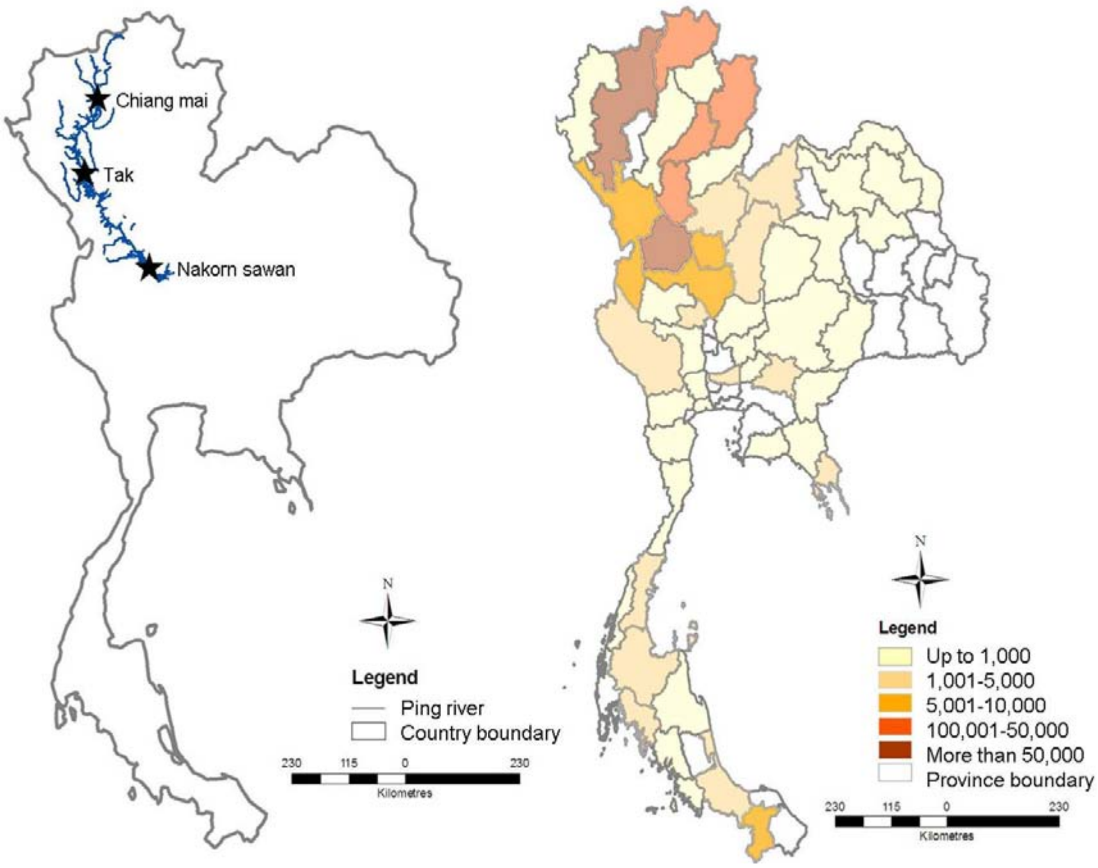

Figure 1-1: Ping river (left) and density of citrus cultivation (rai) (right)

For a decade, cultivation patterns in the basin have shifted from paddy fields to perennial crops because of higher returns, relatively low labour intensity requirement for orchard production, and previous policies promoting monocrop plantation. Among the new horticultural practices carried out in the river basin, citrus is one of the most preferred fruits grown. Figure 1-1 (right) illustrates the high density of citrus cultivation in the Ping river basin. There is an obvious difference in the cultivation systems between upstream and downstream areas (Figure 1-2). Drip irrigation and mini-sprinkler system are widely seen in the upstream part of the Ping river where farms are located in hilly areas. A water pump is needed to lift the water, or the mountainous terrain allows gravity flow to the tanks if water is tapped at upstream sites. In contrast, a raised-bed system of cultivation with ditch irrigation systems is mainly seen in the downstream part of the Ping river. Citrus trees are grown in raised-beds and water is distributed throughout the field via unlined canals.

Figure 1-2: Cultivation system in upstream area (left) and downstream area (right)

Citrus farmers from the central area of Thailand are increasingly migrating to the Ping river basin to find new arable land. Cultivated areas have expanded rapidly and become a source of nonpoint source pollution. It is reported that citrus cultivation has the highest average intensity of insecticide usage compared to other cash crops (Jungbluth 2000). Excess application of chemicals, such as fertiliser and hormones is also applied to boost yield and to preserve quality of the fruit (Namruengsri 2005). Moreover, encroachment of citrus farms into reserved forest areas causes forest loss and acceleration of soil erosion, which is as high as 7.77kg/m^2 per annum (Marod et al. 2005). For these reasons the Ping river basin is susceptible to pollutant contamination, and prevention measures are needed to regulate the discharge of pollutants into waterways. Recently, PCD has initiated the use of BMPs to control pollution at the farm level (Water Quality Management Bureau 2006). The next section gives an overview of citrus BMPs, and discusses the criteria to select BMPs for this thesis.

1.1.3 Best Management Practices (BMPs) on citrus farms

Improperly managed agricultural activities in citrus farms such as overuse of pesticides and nutrients, insufficient soil erosion control and inappropriate water resource management have substantially affected water quality (PCD 2005; US EPA 2000; Tonmanee and Kanchanakool 1999). The discharge of nonpoint source pollution is unobservable due to its characteristics. Therefore, the best alternative to control this pollution is to manage the source and delivery of pollutants by restricting them from contacting watercourses, or a source management approach (Loehr 1984). Global experience suggests that there is a general regulatory preference for voluntary behavioural changes rather than more punitive measures or more administratively complex economic incentive measures (Yeager 2007; Segerson and Wu 2006; Woodhead et al. 2004). One of the solutions to the pollution problem lies in finding adequate management techniques often called Best Management Practices (BMPs).

BMPs are farm-scale management practices to control the generation and delivery of pollutants into water resources. BMPs are widely introduced in order to intercept pollutants before entering watercourses. Concerns over nonpoint source pollution abatement to improve water quality have been gradually changed from programme-by-programme, source-by-source, and pollutant-by-pollutant methods, to more holistic watershed-based strategies (Ioris 2004; Helmer and Hespanhol 1997). The history of BMPs development includes recognition of a potential water quality problem, identification of alternative management solutions, adoption of practical BMPs, implementation of the BMPs and monitoring the success of the adoption (Ice 2004). The United States has recognised the problem of diffuse pollution from citrus cultivation for many years, and established a regional programme of action to address the issue (Parsons and Boman 2006; Florida Department of Consumer Services 2005; 2004; US EPA 2000). The BMP concept, as developed in the United States, therefore provides a list of measures for citrus farming.

Recent concerns with environmental health in a watershed have highlighted the need for citrus farmers to minimise the adverse effects of their farm operations. In general, the most pressing concerns identified as injurious to watershed are sufficient amount of water supply, sediment transport, pesticides, nutrients and aquatic plants. The major groups of BMPs and their main objectives are presented in Table 1-4. BMPs are operational procedures that are normally introduced to farmers as a total package. However, not all BMPs are applicable to any particular citrus operation. Therefore, prior to adoption of any BMP the issue of BMP applicability should be considered.

Table 1-4: Major BMP groups and objectives

BMP groups	Objectives
Water supply	Minimise off-site discharges after excessive rainfall
Sediment transport	Minimise the movement of sediment off-site
Pesticides	Minimise the off-site transport of pesticides and metals
Nutrients	Minimise the movement of nutrients off-site

Source: adapted from US EPA (2000)

The question is how to define and select BMPs for the evaluation in this thesis, and to what extent the selected BMPs might be applicable in the Ping river basin. In order to set standard on the selection of BMPs, the author assembled a set of what might be termed as 'benchmark' reference documents. Literature search was conducted, and sources of information were from the US EPA (2000), Florida Department of Agriculture and Consumer Services (2004; 2005), and Parsons and Boman (2006). The complexity in BMP selection dealt with the breadth of practices and their effectivenesses. These issues are beyond the personal judgement of the authors, and the selection was undertaken in consultation with academics and representatives from government agencies.

To do this, BMPs from the benchmark studies were listed and presented to the experts[3]. A data matrix (Figure 1-3) was used to categorise BMPs. The matrix consisted of two dimensions, which were purposes of BMPs adoption and functional categories of BMPs. The

[3] The expert panels included i) Dr Sanchai Tantayaporn, former Deputy Secretary-General, Deparment of Agriculture; ii) Assoc Prof Dr Charlie Navanugraha, Faculty of Environment and Resource Studies, Mahidol Univeristy; iii) Wit Namruengsri, Horticultural Research Institute, Department of Agriculture; iv) Pornsiri Kanayai, Royal Irrigation Department; and v) two anonymous government officials.

purposes of adoption were classified into four groups, and were: water resource management; erosion control and sediment management; pest management; and nutrient management. The functional categories represented BMP management approach, and were: Good Husbandry; Vegetative Practice; and Structural Practice.

Purposes of BMP adoption	**Functional categories of BMPs**		
	Good Husbandry	Vegetative Practice	Structural Practice
Water resource management			
Erosion control & sediment management			
Pest management			
Nutrient management			

Figure 1-3: Data matrix to categorise BMPs

The next step was a BMP selection. In general, effectiveness is an important criteria in the selection of BMP. However, in this thesis neither field experiment nor simulation model was done to examine BMP efficiency. As such, information of the effectiveness of all BMPs in terms of key pollution variables (e.g. BOD, N and P) is not available. Rather, a broader array of BMPs from literature was identified as appropriate for managing citrus farm pollultion. The experts then evaluated and selected BMPs based on other four criteria.

First, to gain farmers' acceptance the selected BMPs should have a low cost especially installation costs such as materias and labours. Second, the selected BMPs should be easy to implement. This means that the technology is not complex and does not dramatically change farmers' routine practices. Third, the selected BMPs should be feasible and practical. There should not be any physical constraints at the site that may restrict or preclude the use of BMPs. Forth, a regular maintenance for selected BMPs should not be costly regarding who should responsible for the maintenance and what equipment is required to perform the maintenance. Additionally, it should be noted that most of the experts are policymakers who are apt to know applicable national policies regarding the implementation of BMPs. Accordingly, to a degree, the selection of BMPs is based on the likeliness that they will be promoted in the Ping river basin.

Based on the expert judgement, the short list in each of the categories was decided, and twelve measures were selected for the analysis. Table 1-5 outlines the final twelve BMPs.

Twelve BMPs included in this thesis are consistent with, or exceed minimum requirements, contained in the benchmark documents. Based on the main functionality of each BMP, there were three BMP categories. First, Good Husbandry contained four BMPs, which were a maintenance of watering system, an herbicide application within tree canopy, restrictions in pesticide application and a soil analysis. Second, Vegetative Practice included a vegetative cover, mulching techniques, vegetative buffer strips, and grassed waterways. Third, Structural Practice contained an on-site pond, a terracing system, a mix-load and wash-down site, and riparian setbacks.

Table 1-5: Descriptions of selected BMPs

Good Husbandry	
Work load based on the daily work and personal responsibility of farmers.	
Scheduling water structure	Maintenance irrigation or watering structures during dry season.
Apply herbicide within tree canopy	Apply herbicide or mow only within the canopy dripline of the tree.
Basic restrictions for pesticide application	Keep record of all pesticide applied. This includes brand/ product name, total amount applied, target site/ location of application site, application time, and method of application. Also, maintenance and calibrate all spraying machines.
Soil analysis	Test of organic matters and apply fertiliser, in particular organic fertiliser, to match with crops' need.
Vegetative Practice	
Need a regular interval of inspection in order to ensure proper functioning.	
Vegetative cover	Keep grass or vegetation cover on the soil surface in between tree line.
Mulching	Use protective blanket of straw, residue, gravel or synthetic material on soil surface.
Vegetative buffer strip	Buffer strips consisting of planted or naturally occurring vegetation, such as shrubs, trees, and plants are recommended for any cultivated land with less than a 45 degree slope.
Grassed waterway	Construct grassed waterways, repair and reseed bare or eroded spots quickly.
Structural Practices	
Mainly engineered control devices and systems requiring high amount of initial investment costs.	
On-site retention storage	Build of retention pond.
Terracing	Create wide steps on a gentle gradient. This is recommended for cultivated land with more than 30 degree slope.
Mix-load and wash-down site	Build permanent station minimally consisting of a concrete containment pad with a collection sump, a water supply and a roof to minimise entry of wind-driven rain.
Riparian setbacks	Establish distances, approximately 30 meters width, between natural watercourse and cultivated area.

Notes:

1) The benchmark documents were US EPA (2000); Florida Department of Agriculture and Consumer Services (2005; 2004); and Parsons and Boman (2006).
2) More details about BMP functions are described in Chapter 3.

On the other hand, four BMP groups were identified based on the purpose of, and the major consequences from, the adoption. First, a maintenance of watering system, vegetative cover and on-site pond were recommended in order to secure water resource. Second, herbicide applications, mulching, and terracing farming aimed to reduce the rate of soil erosion. Third, safe applications of pesticide, vegetative buffer strips, and a mix-load and wash-down site were to reduce the impacts from pesticide application. Fourth, a soil analysis, grassed waterways, and riparian setbacks were to manage the amount and timing of nutrients application.

1.2 Research Objectives

1.2.1 General statement

The nature of nonpoint source pollution suggests that direct effluent discharge regulation is unfeasible and managing pollutants at source might be more cost-effective. BMPs, from an economic perspective, are a preferable solution for nonpoint source pollution management with the side-effect of broader environmental benefits (Stanley 2000). Considering BMP adoption as a common voluntary approach to tackle farm pollution, many studies have attempted to investigate factors that determine farmers' willingness to adopt BMPs (Campbell et al. 2004). However, in the promotion and marketing of voluntary approaches, there is often an implicit assumption that farmer behaviour towards adoption are homogenous, suggesting a surprising lack of research around behavioural responses to environmental policy instruments (Shogren and Taylor 2008). This suggests that more research needs to be focussed on identifying underlying attitudinal positions that may then explain alternative behavioural responses.

Further, the study of BMP adoption entails a challenging problem in cooperation because BMPs often involve short-term costs for a producer, while the benefits are often long-term and uncertain (Lubell and Fulton 2008). The ensuing debate is not helped by an absence of a scientific evidence-base specifically linking the emerging agricultural causes and impacts of nonpoint source pollution. As the adoption of BMPs imposes costs on farmers, government might consider an intervention to provide incentives for farmers to participate. A study to understand farm level costs and to assess the costs and benefits involved across the whole life of the BMP programme is needed to inform policy decisions.

1.2.2 Objectives of the study

The general objectives of this thesis are: i) to understand the behaviours and attitudes of citrus farmers in their decision on BMP adoption; and ii) to consider policy implications in the context of potential payment for ecosystem services (PES) programmes in Thailand. The more specific objectives of this thesis are outlined as follows:

A) Cost investigation

A1) To investigate the cost components of each BMP;

A2) To explore the extent to which farmers' perceived costs can affect stated adoption intention

B) Behavioural intentions

B1) To understand farmers' conservation behaviours and underlying determinants of behaviour;

B2) To identify the most preferred BMP amongst farmers;

C) Attitudes study

C1) To address differences and similarities in farmers' beliefs and attitudes towards BMPs

D) Policy implications

D1) To make policy recommendations regarding the development of PES programme to protect water quality from farm pollution

1.3 Research Methods

The ultimate aim of this thesis is to make policy implications. Typically, policymakers are faced with at least three challenges. The first is how to investigate real information from stakeholders, and to understand the underlying logic that could result in adoption behaviour. The second are the factors that potentially affect willingness to adopt such policies. The third is how to translate the needs of stakeholder to development agencies. The array of objectives addressed in this thesis requires multiple approaches for collecting and verifying information, which then will offer insights for policy implications. As such, three independent studies are proposed and are: i) a farm cost analysis; ii) an application of the

Theory of Planned Behaviour (TPB) and associated statistical analysis; and iii) an application of Q-Methodology and Q factor analysis.

Figure 1-4 illustrates stand-alone objectives of each study and its contribution value for policy implication addressing a water-related PES programme. First, the farm cost analysis is proposed to investigate the cost component of each BMP. It is expected that information on economic costs can be used to further explore the extent to which farmers' perceived cost may affect their stated intention to adopt a variety of BMPs. Overall, results offer an understanding of the total costs incurred by farmers and to provide information on incentive levels for policymakers, given that financial assistance is needed to induce farmers' participation.

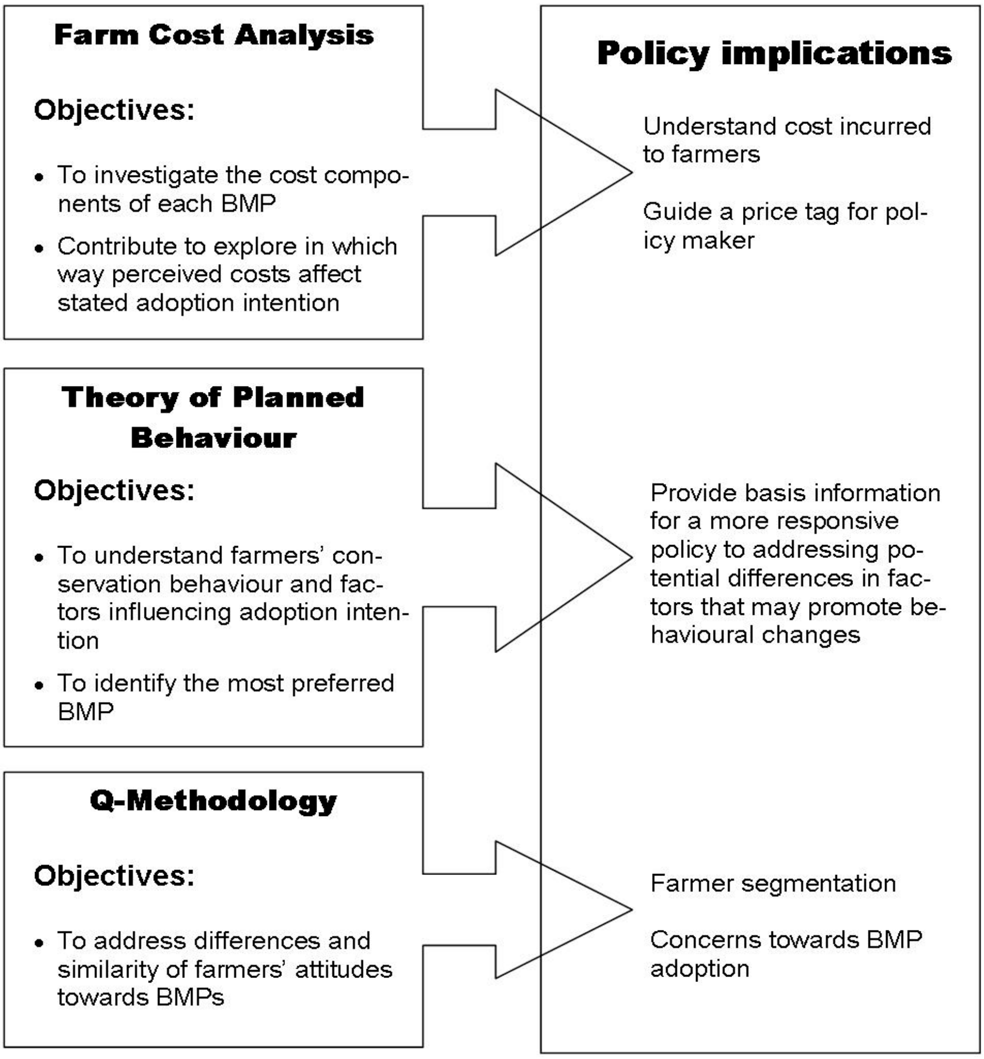

Figure 1-4: Stand-alone objectives and contribution values for policy implications

Second, the application of TPB and statistical analysis are expected to give insights into dominant factors influencing the adoption, and to identify the most preferred BMPs amongst farmers. These findings will provide basic information for the design of more responsive environmental policy according to differences in psychological and socio-economic variables between farmers. Third, the Q application is used to investigate farmers' latent attitudes and to identify the ways environmental issues are perceived. The technique of factor analysis can segment farmers based on their perceptions towards BMPs. This information is useful for an in-depth analysis to discover farmers' concerns, which could deter BMP adoption.

1.4 Thesis Structure

This thesis contains seven chapters (Figure 1-5). Chapter 1 presents the background to water pollution in Thailand, and highlights farm nonpoint source pollution as one of the major causes. It reviews the current state of citrus production in the Ping river basin, which is the case study in this thesis. A risk of water contamination from intensive farming has suggested a need for preventive measures. In this chapter, twelve BMPs have been proposed as tools to control and manage farm pollution at the point of origin. This is followed by research objectives and research method.

Chapter 2 reviews the research rationale and methodologies. It presents a general overview of water pollution, and its negative impacts. The economic perspective on the causes of water pollution is reviewed. This is followed by a series of pollution control approaches, which highlight the command and control approach and market-based instruments. Particular attention is paid to payment for watershed service (PWS) as a forming market-based transaction. This chapter also reviews the methodologies proposed in this thesis. It discusses the weaknesses of the rationality assumption inherent in traditional economic theory, and suggests that alternative approaches are needed to investigate underlying factors in adoption decisions making.

With the notion that cost is the main barrier for adoption new practices, chapter 3 offers the analysis of costs incurred by farmers. Total costs of twelve BMPs, including first year installation costs, annual maintenance costs, and opportunity costs of land are estimated. For the comparison purpose, these costs are subjected to annualisation. The cost estimates also provide information for the investigation of how perceived costs may affect farmers' adoption decision, which is proposed in chapter 5.

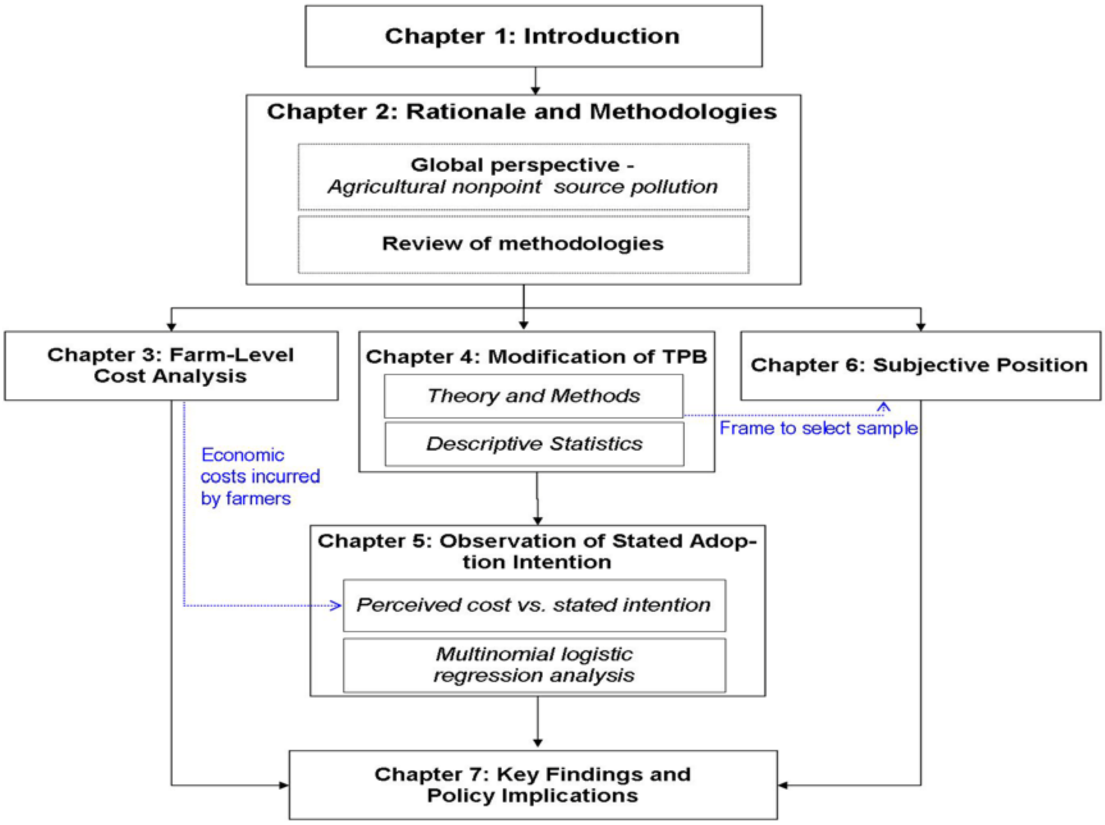

Figure 1-5: Thesis structure

Following the theme discussed in chapter 2, chapter 4 offers a study based on TPB. It outlines the main constructs of TPB, and discusses psychological variables and other external variables to the theory. This chapter also sheds light on elicitation study and content analysis, which are needed in the early stage for questionnaire development. It then introduces the fieldwork which focused on the household survey, explaining the sampling method, sample size calculation, and data collection. The personal interviews are conducted with 218 farmers. Of these, 126 are upstream farmers and 92 are downstream farmers. Moreover, this chapter provides a descriptive characterisation of farmers, explores the most preferred BMPs amongst farmers, and illustrates the differences between farmers in the upstream and downstream of the Ping river basin. These findings offer basic information for the analysis in chapter 5 and chapter 6.

Chapter 5 takes up the issue of the factors influencing BMP adoption in greater detail. Drawing information from chapter 3 and chapter 4, it first explores the way perceived cost, occurring at the time decision is made, may influence farmers' stated adoption intention. To illustrate a relationship between these two variables, data are presented in a graphical form. This interpretation is supported by the results from farmer interviews. Moreover, adopting information from the descriptive statistics in chapter 4, this chapter then proceeds to examine the influence of psychological and external factors that influence farmers' adoption intention, through a logistic model. The results from the best fit model are presented and discussed.

Chapter 6 adopts Q-Methodology and focuses on the study of subjective positions based on farmers' perception of BMPs. A TPB sample of 218 farmers is used as a sampling frame for this study. To get a representative samples of farmers based on farm size, education level and age, 72 farmers are selected for the Q analysis. This chapter discusses the development of concourse and criteria to select statements for a sorting process. In the survey, farmers are asked to sort these statements and are followed-up with the interviews. Factor analysis is used to segment farmers according to their preferences towards each statement. Characteristics of each farmer group are explained based on salient statements and supporting information from the interviews.

Chapter 7 concludes the key findings from the empirical works in each chapter. These findings then contribute to a discussion about the possibility to development a water-related PES programme, and offer insights for policy implications. This chapter then outlines the limitations of methodologies employed in this thesis and recommends directions for future improvement. Finally, the recommendations for future work in the context of knowledge integration between economics and ecology are discussed.

2 RESEARCH RATIONALE AND METHODOLOGY REVIEW

Nonpoint source pollution generated by farm activities can spread throughout the watershed and discharge into water bodies. In Thailand, the problem of water pollution is one of the greatest national concerns. Thailand has witnessed an increase of organic water pollution since 1980s (The World Bank 2001). Recently, the government has initiated a BMP programme to control farm nonpoint source pollution at the watershed level. In this thesis, citrus farming in the Ping river basin is used as a case study because traditional farm management, such as intensive use of chemicals and fertiliser, and forest encroachment (which induces soil erosion), have contributed to water contamination. As applied in developed countries, such as the United States, BMPs are accepted as a potential tool for coping with nonpoint source pollution (US EPA 2003). However, the extent to which these practices will be voluntarily adopted by Thai citrus farmers is questioned.

Accordingly, this thesis aims to investigate farmers' behaviour and attitudes towards the adoption of BMPs in the management of farm pollution, targeting the improvement of water quality. This chapter presents a general overview of water pollution as a consequence of farm nonpoint source pollution, and reviews methodologies proposed in this thesis (Figure 2-1). The first section (section 2.1) offers an overview of water quality degradation and is followed by a discussion of water pollution problems from an economic perspective. It then proceeds to highlight the command and control approach (CAC), and market-based instruments (MBIs), mainly focusing on payment for ecosystem services (PES) and the development of BMPs in developed countries.

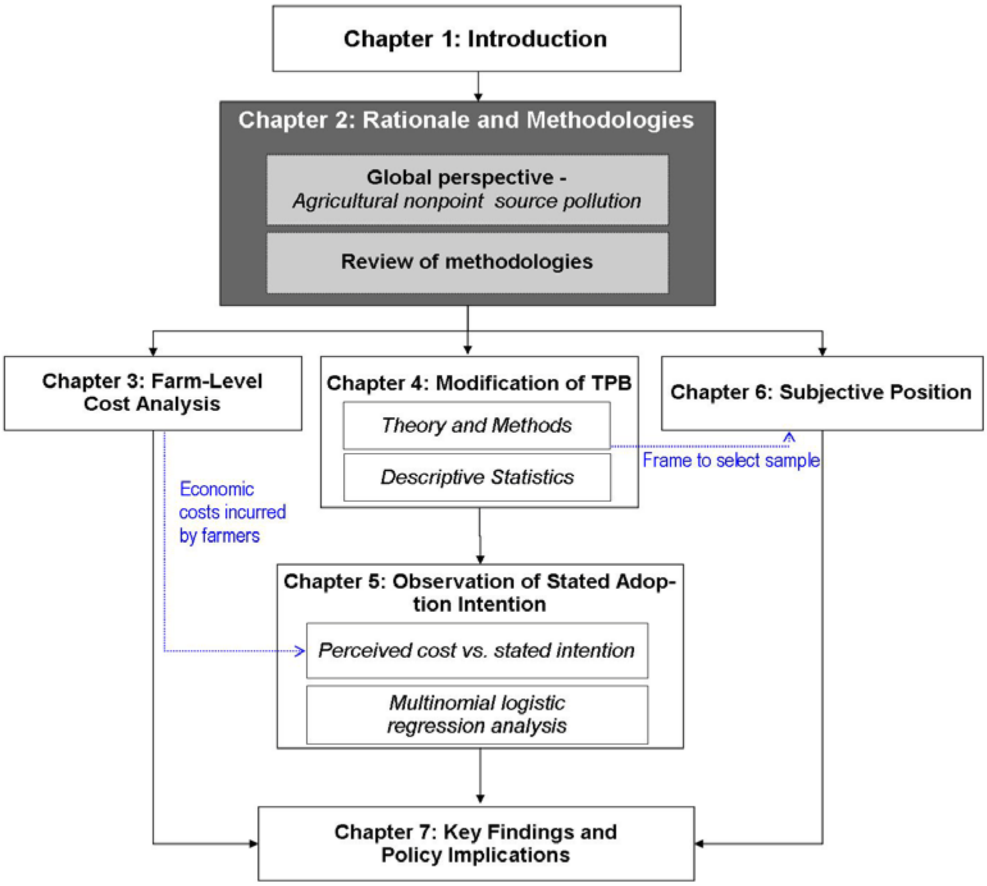

Figure 2-1: Thesis structure

The second section (section 2.2) presents methodologies used in this thesis. Specifically, an analysis of the limitations of neoclassical economic assumptions in relation to adoption behaviours, calls for an alternative analytical approach to guide effective policy intervention. Alternative decision theory, the Theory of Planned Behaviour (TPB), and Q-Methodology are reviewed. This chapter closes with a summary (section 2.3) of key issues.

2.1 A Global Perspective of Agricultural Nonpoint Source Pollution

This section reviews the problem of water quality deterioration as a result of farm pollutants, often known as nonpoint source pollution. It begins with a definition of nonpoint source pollution, and the impacts of farm discharges on the water quality of the receiving water. Causes of water pollution are discussed in an economic context. Further, the roles of a traditional CAC and MBIs, which are inspired by the polluter pays principle (PPP), are also discussed. This leads to a review of the concept of PES as an economic incentive approach for any individual providing flows of ecosystem services. The review in the following section further focuses on a typical characteristic of payment for watershed service (PWS) at a global scale. This section is closed by a review of the establishment of designed contracts, known as BMPs, in developed countries.

2.1.1 An overview of water quality degradation

Water pollutants are normally sorted into point and nonpoint sources (Peirce et al. 1998). Some differences between point and nonpoint sources are shown in Table 2-1. Point source pollution, especially from industrial and urban wastewater, is regarded as a main source of water pollution. Point source pollution has been managed through command and control strategies, and the construction of wastewater treatment plants in pollution prone areas. Currently, challenges are presented by nonpoint source pollution and specifically water pollution as a result of agricultural activities. This has become a major concern in many countries (Segerson and Wu 2006; Gunningham and Sinclair 2005; Xepapadeas 1995).

Table 2-1: Comparisons between point and nonpoint source pollution

Point source pollution	**Nonpoint source pollution**
Enter the receiving water bodies at some identifiable single or multiple point location carrying pollutants.	Enter the receiving surface waters in a diffuse manner at intermittent intervals that are related mostly to the occurrence of meteorological events.
Efforts to clean point source pollution intensify and billion were spent on the installation of treatment plants.	Difficult or impossible to be monitored at the point of origin.
In most countries these sources are regulated, their control is mandated and a permit is required for the waste discharges from these sources.	Abatement of diffuse load is focused on land and run-off management practices.

Source: adapted from Campbell et al. (2004); Novotny (2003)

Water pollution happens when the pollutants move from land to water bodies (Frost 1999). The US EPA (2003) identifies six main sources of water pollution caused by agricultural practices. These are erosion and sedimentation, animal waste, nutrient, pesticide, grazing management and irrigation water management. The relative importance of pollutant concentration for each agricultural activity is different (Table 2-2). For example, crop production in non-irrigated farms contributes to high concentrations of suspended solid/sediment, nutrient, and pesticide in water, but it might have negligible acidity effect on overall water quality.

Table 2-2: Relative importance of pollutant concentrations

Category	Suspended solids/ sediment	BOD	Nutrients	Toxic metals	Pesticides	Pathogens	Salinity / TDS	Acids	Heat
Non-irrigated crop production	H	M	H	N-L	H	N-L	N	N	N
Irrigated crop production	L	L-M	H	N-L	M-H	N	H	N	N
Pasture and rangeland	L-M	L-M	H	N	N	N-L	N-L	N	N
Animal production	M	H	M	N-L	N-L	L-H	N-L	N	N

Notes: 1) TDS = Total Dissolved Solid; BOD = Biochemical Oxygen Demand
2) N = Negligible; L = Low; M = Moderate; H = High

Source: Peirce et al. (1998)

Consequences of nonpoint source pollution on water quality are typically different from place to place and from time to time (examples of studies are Wang 2006; Ichiki et al. 2003; Nakasone and Yamamoto 2003; Agrawal 1999; Bendoricchio et al. 1999). In general, nonpoint source pollution from agricultural activities contributes to poor water quality by means of, for example, deterioration of aquatic habitats, eutrophication, in-stream photosynthesis reduction, and turbidity (Campbell et al. 2004). The negative environmental impacts from poor water quality represent a market failure, in that these negative externalities impose unwanted costs on society (Bromley 2007). As water quality is not always traded in the market, this results in a socially inefficient level of output and/ or consumption. The term market failure is used to describe the condition in which equilibrium in markets fails to achieve an efficient allocation of goods and services, or the condition in which social marginal benefit is not equal to social marginal cost (Zerbe and McCurdy 2000). Economists have defined causes of market failures, and these are discussed as follows.

2.1.2 Water pollution: an economic perspective

In terms of economics, a market refers to any set-up that enables an interaction between consumer and producer to exchange a well-defined commodity. By ‘set-up’ a market needs not require a location where exchanges are operated, for example an online market (Aldridge 2005). In microeconomic theory a buyer’s behaviour is illustrated by demand, while a seller’s behaviour is presented by supply. Demand is defined by the quantity of goods and services that consumers will buy at each and every price charged, whereas supply is the quantity of goods and services offered by producers at each and every possible price. A transaction may happen at a dictated price, but an equilibrium price can be established by the interaction of demand with the quantity available of supply (Begg et al 2003). However, sometimes the market is unable to perform its function effectively. In the context of water pollution, it does not reflect all costs of products or where demand is not clear. Three main causes of market failure are appeared: the characteristics of common pool resources (CPR), externality, and lack of property rights.

2.1.2.1 Characteristics of common pool resources (CPR)

Goods and services are defined by two important attributes, which are excludability and subtractability (Figure 2-2). Excludability refers to a prevention of an individual who does not pay for that thing from enjoying the benefit of it. Subtractability deals with the situation whenever consumption of someone diminishes the availability to consume by another. Water quantity and water quality are examples for a typical CPR (Sarker et al. 2008a). It is difficult to exclude others from consumption and the water body is easily depleted. For example, access to watershed services such as flow regulation and water quality control are not easily limited, and the amount of water consumed or polluted by people living upstream is unavailable for those living downstream.

		Subtractability	
		Low	*High*
Excludability	*Difficult*	Public goods or free goods	Common pool resources
	Easy	Toll or club goods	Private goods

Figure 2-2: Natures of goods and services
Source: adapted from Carpenter (1998); Ostrom et al. (1994)

Regarding the characteristics of CPR in which all users have equal access to the resources, degradation of resource systems is likely to continue as long as individuals enjoy the value derived from resource units (Dietz et al. 2002). Difficulty in exclusion of consumption and a high degree of subtractability can cause excessive resource exploitation. This is a rationale of the so-called 'Tragedy of the Commons' (Hardin 1968). Hardin explained that since private costs of consumption do not reflect total social costs and users logically act to maximise their benefits, whereas the costs of use are generally shared amongst all users. This leads to the destruction and the collapse of the resource.

2.1.2.2 Theory of externalities

Water pollution can also be viewed as an externality issue. Externality exists whenever the activities of an acting party affect the welfare of another party, and the acting party is not faced with the cost of the impact (Prato 1998). In the case of CPR, externalities can be classified into two types, and are within-boundary and cross-boundary externalities (Sarker et al. 2008b). Within-boundary externality occurs when contaminated water reduces the quality of water available to other uses of the same system. Cross-boundary externality occurs when contaminated water affects water quality in downstream catchments. Problems of water pollution also involve unidirectional externalities in that impacts flow downstream (Sarker et al. 2008a).

With pure externalities, people can take no account of costs and benefits that their action imposes on others, and a market failure arises because there is neither a market nor a market price for externality (Begg et al. 2003). An existence of externalities brings about economic inefficiency leading to private equilibrium, and undersupply or oversupply of externalities is not a Pareto optimal (Haab and McConnell 2002). Consider Figure 2-3 (left) under a perfectly competitive market, suppose there are broader costs to society, and the social costs of supply will exceed the private costs. If the producer does not take account of a negative externality by supplying at point E_1 where private maximise profit equals to Marginal Cost (MC) = Demand (D) = P_1= Q_1 , this leads to an oversupply which equalled to Q_1Q_2. If the producer does not concern for external costs, they are likely to produce/ supply at point E_1. However, faced with extra external costs will suggest a rational supply (marginal cost) scheduled marginal social cost (MSC). By counting marginal supply costs with demand, the new MSC will suggest that point E_2 is the optimal level of supply. Hence, by faced with the external cost suggested, the producer reduces their supply of Q_2Q_1.

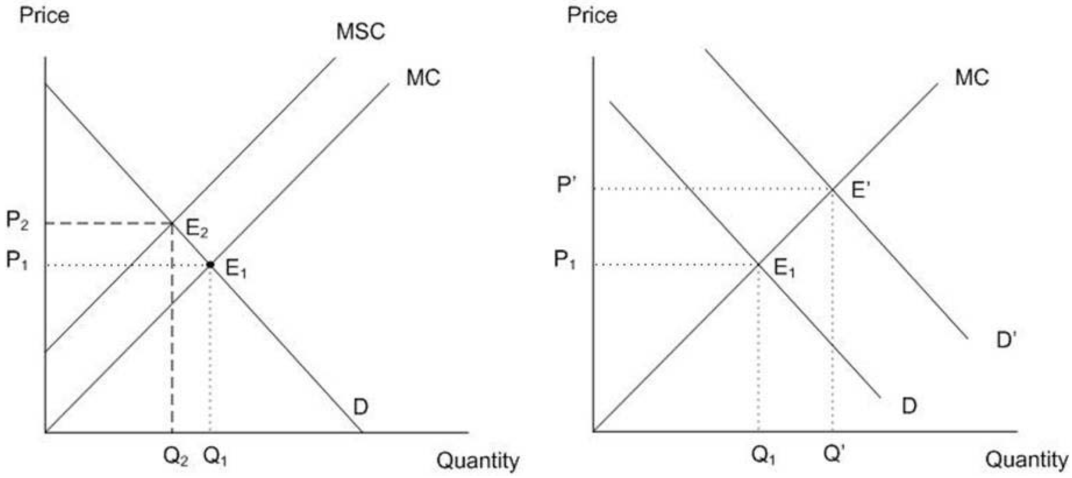

Figure 2-3: Negative externality (left); Positive externality (right)

The negative external costs are oversupplied. In contrast, positive externalities are undersupplied. Consider Figure 2-3 (right), for example, D presents private marginal benefit while D′ presents social marginal benefit. The private marginal benefit includes only benefits received by producers. Suppose that a new technology for pollution abatement is introduced, it will have a social marginal benefit that is higher. If the producer takes only his/ her private benefit into account, the producer will operate at E_1 using less technology rather than at E′. In this case; therefore, total undersupply equals to $Q'Q_1$.

2.1.2.3 Lack of property rights

Market failure can be viewed in terms of an absence of, or weak, property rights (Prato 1998; Papandreou 1994; Boadway and Bruce 1984). Property rights are social arrangements that permit the use and disposal, govern the ownership, and transfer of the ownership of goods and services (Callan and Thomas 2000; Parkin et al. 1997; Bromley 1992). The Coase Theorem (Coase 1960) shows that when property rights are not clearly defined, producers or consumers freely impose costs on others, thus resulting in an economically inefficient outcome.

Consider Figure 2-4 with an assumption of perfect competition in which a market will perform effectively, D presents the market demand curve, and MC presents the market supply curve. MC is the sum of the marginal cost curves above average variable costs for all producers. The market equilibrium is point E_1 where the profit maximising production is Q_1, where P_1 = MC is the privately efficient level of production. At this point, private producers typically do not consider environmental damage caused by their production. For example, runoff from farms carrying inorganic chemicals is released directly into adjacent streams and leads to water quality deterioration.

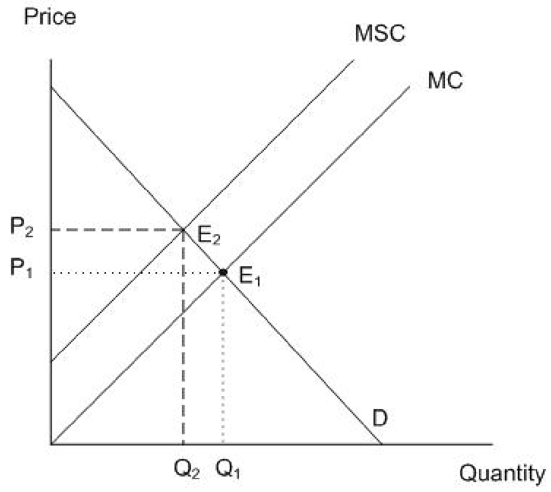

Figure 2-4: Property rights and market failure

Suppose that environmental damages are included in the marginal costs of production, it gives the marginal social costs, MSC, of production. Therefore, the socially efficient level of production is Q_2 where P_2 = MSC. Considering the definition of property rights if farmers are granted a right to pollute water, they discard the environmental damage and select to produce at Q_1, which is their privately profit maximisation quantity. In contrast, if farmers do not have right to pollute water, they must accept to produce at Q_2 which represents a socially optimal quantity. The example clearly shows that with an absence of well-defined property rights, individuals will take advantage of the common resource, bringing about resource degradation.

In the context of CPR, resource degradation occurs because well-defined and enforceable property rights do not exist (Quinn et al. 2010; Bromley 1991). Schlager and Ostrom (1992) identified five property rights with respect to natural resources. These are access, withdrawal, management exclusion and alienation. Access is the right to enter a resource. Withdrawal is the right to obtain products from a resource. Management is the right to make decisions on the resource allocation. Exclusion is the right to decide who should have access, withdrawal and management rights. Alienation is the right to sell or lease a resource. These different bundles of property rights are distributed to different types of property right holders (Table 2-3). For example, the owner of the property holds all five rights, while the authorised user is only allowed to enter and to extract the resource. The sources of these rights may be either enforced by government or defined among resource users (Schlager and Ostrom 1992).

Table 2-3: Bundles of rights associated with right holders

Property rights	**Types of right holders**			
	Owner	Proprietor	Claimant	Authorised user
Access	x	x	x	x
Withdrawal	x	x	x	x
Management	x	x	x	
Exclusion	x	x		
Alienation	x			

Source: Schlager and Ostrom (1992)

In terms of agricultural policy, Bromley and Hodge (1990) defined two starting points for an analysis of property issue. The first property structure is the one where property rights are given to farmers. The other is the property right allocated to the state, who acts as an agent for others, such as urban residents, and rural poor. Different property right arrangements will have different production effects, and thereby causing different levels of pollution produced. Hodge (1989) suggested that a reference point can be used to identify who should be responsible for a desirable level of environmental quality (i.e. who should bear the costs of achieving the environmental goals). Two different mechanisms to appropriate the costs of pollution abatement are polluter pays principle (PPP) and beneficiary pays principle (BPP).

Under the PPP, government sets mandatory standards to control and manage farm pollution, and farmers must conform to these regulations. In this circumstance, farmers bear the costs such as forgone production income, and investment in new technologies. On the other hand, the BPP proposes that desired environmental goals could be achieved through government incentives and a voluntary adoption of conservation practices. Farmers adopt innovations for the available funds, which are normally collected from taxpayers.

Overall, the issue of market failure in relation to water pollution is characterised by the problem of externality, ill-defined property rights, and the characteristics of CPR. The existence of externalities leads to a private equilibrium which is not optimal. Externalities can be solved if an affected party is compensated for a loss of welfare (Aldridge 2005). Coase (1960) proposes two stringent approaches: an institution of legal property rights and direct government regulations to specify rights and lessen the externality problem. Coase (1960) proposes that the establishment of defined legal property rights in a perfectly competitive market, with zero transaction costs, can remove existing externalities. If externality is internalised, economic efficiency where the marginal social costs equal to the marginal benefit costs is achieved.

However, the establishment of property rights is sometimes practically ineffective in the political process (Rose 2002). Government has power to establish property rights, but different political goals could bend the assignment of property rights. For example, policymakers may be faced with different types of incentive in enforcing claims to properties. Land allocation could be viewed as an additional instrument to favour and gain supporters. Moreover, in the real world, transaction costs are always greater than zero (Zerbe and McCurdy 2000). Accordingly, direct government regulation is often preferable in dealing with externality problems.

The nature of agricultural nonpoint source pollution is that pollutants are normally discharged into surface water by land-based agricultural activities (Frost 1999), which then will be spread throughout a watershed. An incident is an intermittent interval related to climatic conditions, in particular, rainfall, and it is unlikely to be monitored or controlled at the point of origin (Novotny 2003). In an attempt to correct market mechanisms, government agencies have intervened and chosen a number of different policy instruments. A summary of pollution control approaches is discussed as follows.

2.1.3 Pollution control approaches

The nature of nonpoint source pollution requires that efficient regulation should focus on land-use activity, rather than end-of-pipe control. Farm nonpoint source pollution is an externality that can be addressed using various forms of government regulation (Novotny 1998). Policies focusing on pollution control have been inspired by the polluter pays principle (PPP), which is influenced by Pigou's (1920) writings. PPP was first defined and recognized as an internationally agreed principle by the Organisation for Economic Cooperation and Development (OECD) in 1972 (OECD 1972). The PPP expresses that agents generating pollution should be faced with its full costs. In order to enact the PPP, definitions of pollution and polluter must be clearly defined. According to the OECD (2002), pollution has been identified as direct and indirect substances or energy introduced by humans into the environment causing harmful effects on nature as to threaten human welfare, while the polluter is the party responsible for the polluting activities.

By adopting the PPP, externalities can be internalised because the costs of environmental destruction are distributed between producers and consumers who are engaged in the activity. The costs may be shifted downward or upward in the market, and the costs of pollution are internalised into the costs of the product (Rogers 1996). To date, the PPP is being implemented through two different policy approaches. These include a command and control approach, and the use of market-based instruments. The mechanism, advantages and disadvantages of each approach are outlined as follows.

2.1.3.1 Command and control approach

A command and control (CAC) approach is established to discourage environmentally harmful activities. Stavins and Whitehead (1992) state two broad types of CAC approach. These are technology-based and performance-based CAC approach. The technology-based CAC approach specifies the methods and equipment that producers must adopt to reach a target, while the performance-based CAC approach implies setting an overall target for every producer, and giving freedom to producers on how to manage to achieve the standard.

Asafu-Adjaye (2005) presents three types of standard relating to the CAC approach. Firstly, the ambient standard limits the maximum level of pollutants in a given environment. It is typically represented as an average concentration level over some period of time. Secondly, the emission standard allows a maximum level of permitted discharge. Lastly, a technology standard indicates the specific technologies, techniques or practices that producers must adopt or install. Examples of CAC are guidelines and permits, federal regulation, uniform pollution standards, and technology mandates.

CAC approach offers numerous potential advantages (Harrington and Morgenstern 2004; Barde 1994), for example:

1. There is a longstanding experience with the application of CAC approach in other fields, such as health and safety.

2. CAC approach is the most efficient measure if, for every polluter, the marginal cost of abatement equals to the marginal cost of pollutant damage.

3. Since the standard is precisely set, the objectives can be attained quicker with greater certainty.

4. The polluter prefers CAC approaches to other instruments because of lower implementation costs. That is, the polluter is responsible for only expenses relating to pollution abatement.

Despite these strengths, there are some concerns about the shortcomings of the CAC approach. Harrington and Morgenstern (2004) explain a rationale of high administrative cost caused by the huge amount of interaction between the regulator and regulated source and the complexity of arranging and applying obligations. Portney (2003) argues that under the CAC approach there is no incentive to invent new technology or modify present processes, and a pollution control technique will be fossilised. Pagiola and Platais (2002) state that polluters will be penalised if they do not follow the regulations, so polluters may have an incentive to conceal their actions. Moreover, Tomich et al. (2004) believe that the CAC approach is not suitable to apply with environmental policy because of its nature that possibly leads to counterproductive behaviour and excludes the poor from the source of living.

2.1.3.2 Market-based instruments

Another approach to control pollution is known as market-based instruments (MBIs). MBIs are generally defined as mechanisms within which property rights are voluntarily exchanged through pecuniary compensation (Whitten et al. 2003). According to Portney (2003), MBIs is a maneuver of government intervention to protect resources by fostering and pushing a market to work in the service of the environment. The use of MBIs is becoming more widespread, and it is obvious that MBIs are used as complementarities with CAC approach in mixed systems other than being used as substitutes for regulations (Nicolaisen et al. 1991). OECD has identified seven types of MBIs (Barde 1994). These are emission charges or taxes, user charges, product charges or taxes, administrative charges or fees, marketable permits, deposit-refund systems, and subsidies.

The implementation of MBIs offers numerous advantages (Bishop et al. 2006; Harrington and Morgenstern 2004; Gouyon 2003; Pagiola 2002; Austin 1999) as follows:

1. Compared with a traditional direct government regulation, MBIs are more cost effective and more flexible in promoting innovation over times.

2. By employing the measure, enforcement costs are reduced due to better alliance between private and public interests.

3. MBIs, such as tax, can be a source of revenue for government because rights to pollute can be formally traded in arranged markets.

4. MBIs, such as payment for ecosystem services, can be an additional source of income for the rural poor if the poor families are providers of natural resources.

5. MBIs offer greater capacity in dealing with smaller and nonpoint source pollution such as agriculture runoff. Moreover, they allow for hands-off regulation and decentralised decision-making as well as allowing polluters to act freely provided that all requirements are met.

Though MBIs are superior to CAC regulation mechanisms in terms of efficiency of implementation and effectiveness of outcomes (Harrington and Morgenstern 2004; Austin 1999), the approach suffers some drawbacks. Harrington and Morgenstern (2004) claim that polluters under MBIs are charged higher costs than those directed by the CAC approach because they are asked to pay a fee for the remaining pollution. Moreover, the application of

MBIs can cause unpredicted amounts of pollution especially in cases of taxation where polluters are allowed to release waste as much as they want as long as they can pay for the tax. Tomich et al. (2004) argue that the development of MBIs in the real world is difficult since each polluter faces different cost structures and the optimal reward is not easily determined. Finally, the implementation of MBIs possibly leads to undesirable outcomes if they are designed to promote political or ideological agendas instead of compensating an affected party.

It is obvious that most MBIs have been initiated through public policies despite the fact that privately negotiated incentive-based solutions are possible. Recently, interest in payments for more direct transactions (e.g., private-public, private-private) has led to a focus on PES. PES has been introduced as a policy solution for realigning the private and social benefits resulting from decisions relating to the environment (Jack et al. 2008). PES has a characteristic of MBIs, and it is different from CAC in that it lets the price mechanism works to allocate resources. Though CAC may also affect the market, it does not have a direct impact on either cost or price. Level of farm pollution is fixed by mandatory regulations, but not by individual's economic preferences.

2.1.3.3 Payment for ecosystem services

An ecosystem service is a benefit of nature, directly or indirectly enjoyed and/or consumed to sustain and raise human wellbeing (Costanza et al. 1997; Daily 1997). The Millennium Ecosystem Assessment (2005; 2003) identified four categories of ecosystem functions as provisioning, regulating, supporting and cultural services[4]. The PES programmes have been adopted by several institutions, such as the World Bank, the International for Environment and Development, the International Union for Conservation of Nature, and the Centre for International Forestry Research. Though there is no global definition of PES programme, PES is commonly classified by five criteria, which are: 1) a voluntary transaction, with 2) a well-defined ecosystem services that is being 3) brought by an environmental service buyer

[4] Provisioning services are products obtained from ecosystems such as food and fibre and fresh water. Regulating services are benefits from the regulation of ecosystem processes such as the regulation of climate and water. Supporting services refer to natural processes that are necessary for the production of other ecosystem services. These are, for example, soil formation and retention, nutrient cycling and water cycling. Cultural services are benefits humans obtain from ecosystems through spiritual enrichment, recreation such as aesthetic values.

4) from an environmental service provider 5) given the service is continuously delivered only when payments are made (Wunder 2005; Wunder et al. 2005).

The rationale of PES is that since landholders do not receive compensation for the services their land generates for the others, they have little economic incentive to take these services into account in the management of their land. Basically, PES is a reward mechanism to support positive environmental externalities. Rewards, or payments, in terms of money or in-kind incomes are transferred from beneficiaries to landholders who provide certain ecosystem services (Figure 2-5) (Wunder 2005; Mayrand and Paquin 2004). The maximum payment from beneficiaries should at least be equal to or greater than the minimum cost incurred by the landholders (Sierra and Russman 2006).

Two extreme cases of cost incured by farmers could happen in the BMP adoption, decreased returns and increased costs. Considering figure 2-5 (left), upstream farmers receive less benefit from BMP adoption (□B) than the benefits they receive from the current farming practices (□A) (i.e. the reduction in fruit quality results in the lower selling price). A transfer payment from downstream beneficiaries (□C) can make the BMP adoption more attractive for the upstream farmers. Figure 2-5 (right) presents the case when cost is increased from the BMP adoption. Operation and maintenance costs, for example, are additional costs (□X) to the current farming practices (□W). A transfer payment from downstream beneficiaries should at least be equal to (□Y) or greater than (□Y + □Z) the total costs incurred by landholders. The ultimate aim of PES is to reconcile conflicting interests through compensation and to find solutions for preserving ecosystem services that are vulnerable because of mismanagement by establishing a missing market and promoting the protection of ecosystem services (Pagiola and Platais 2007).

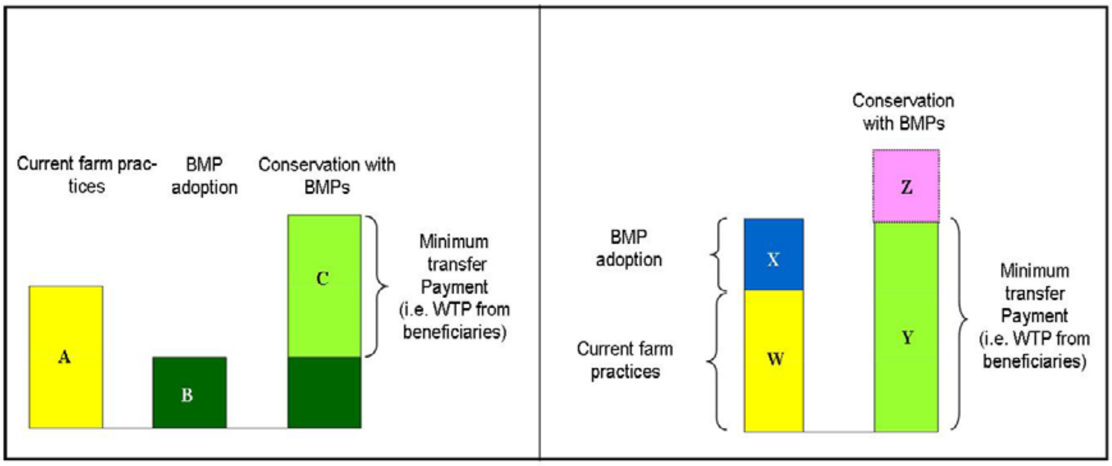

Figure 2-5: Logic of payment for ecosystem services: i) decreased returns (left); and ii) increased costs (right)
Source: adapted from Pagiola and Platais (2007; 2002)

PES is one of the market mechanisms that will properly function only if the potential gains from trade outweigh the costs incurred in the market process. The concept of PES derives from the notion of allocative efficiency, where marginal external benefit is added to marginal private benefit to internalise a positive externality. The possibility to establish PES depends on the concurrence of direct compensation either in monetary terms or in-kind incomes, and development of markets for specific environmental services. The success of PES at any scale requires the right combination between local capacity and a willingness to participate from all stakeholders (Rosa et al. 2004; Whitten et al. 2003).

PES is considered to be more efficient than a conventional CAC approach, especially when applied within a developing countries context (Engel et al. 2008). Past performance of many regulatory and public investments suggested that regulations are difficult to apply if landholders are spatially dispersed (Pagiola and Platais 2002). Additionally, the regulation possibly impose costs on poor land users, preventing them from undertaking individually profitable activities. The public investment especially remedial measures are regularly imperfect and sometimes more costly than preventive measures (Tomich et al. 2004). PES is also superior to the CAC approach in that it can work by creating the incentive system for conservation where the government policy promoting redistribution of resource has failed (Mayrand and Paquin 2004; Whitten et al. 2003).

Furthermore, a PES programme can be adopted as a business-type approach for conservation, which certainly leads to a more sustainable outcome. This is because it offers continuous flows of payments and a viable business in the long run (Bishop et al. 2006; Wunder 2006; Mayrand and Paquin, 2004). PES, in principle, can complete the goal of both environmental protection and poverty reduction. Duncan (2006) defined an 'equitable PES' as any PES that aimed to conserve nature as well as to bring substantial benefits to the poor in a just and equitable way. She argued that the rural poor, including indigenous people, were the key active players in conservation programmes thus they should not be excluded from the beginning of the plan. Rosa et al. (2004) believed that the rural poor had an ability to turn degraded natural resources into an environmentally rich system, producing ecosystem services which could then be sold to outsiders. It is expected that PES as a multipurpose tool will ultimately lead to equitable wealth distribution, increased awareness on the economic value of ecosystems, and economic development as a whole (Kosoy et al. 2007; Pagiola 2005; Landell-Mills 2002).

Though a PES programme offers several advantages, there are some criticisms about its efficiency and payment scheme. The criticisms to programme efficiency are relevant to the lack of permanence and the tangible of additional services. Engel et al. (2008) argued that a permenance of PES programme could be hindered by changes in external conditions such as changes in market prices of agricultural crops competing with natural resource conservation. Further question is whether there is any difference in the provision of ecosystem services between the with- and without-PES programmes (Wunder 2007). Policymakers should aware of these limitations when making policy implications; otherwise a PES programme may put tensions between service sellers and buyers. For example, to address the criticism on PES efficiency, PES contracts should be flexible and provide enough rooms for further amendments such as when new conditions are needed (Engel et al. 2008). It is also necessary that a baseline should be established so that additionality as an incremental service delivered from a PES programme can be determined (Wunder 2007).

Another criticism focuses on the payment scheme leading to the questions of equity and fairness. The PES approach contrasts with PPP in that PES compensates those who provide positive externalities other than imposing additional costs to those who create negative externalities. That is, PES payment mechanism relies on the BPP, and leads to the questions regarding policy implications: Do we pay the right people? Do we pay for the rights that farmers never had? From a pure efficiency perspective, there is no difference either the PPP or BPP is applied (Pagiola et al. 2005). Both PPP and BPP will bring about the same results provided that markets are competitive, property rights are well-defined, and transaction cost is zero (Coase 1960). However, these conditions are unlikely to happen in the real world. As such, a key challenge is to determine the appropriate reference level, or an analysis of property issue raised by Bromley and Hodge (1990).

Most PES programmes are driven by beneficiaries' demand (Landell-Mill and Porras 2002), and this implicitly arranges a demand-driven *de facto* property rights to farmers or landowners. Accordingly, a payment mechanism based on BPP sounds reasonable since farmers have the rights over agricultural land. Salzman (2005) asserted that this situation is different from the case when pollution regulations are set to limit emissions from point sources, such as factory. This is because PPP is inefficient to enforce dispersed nonpoint sources, and we are asking the poors to adopt activities above and beyond what they would have done. Therefore, if beneficiaries want an improvement beyond the current standards, they should pay. This discussion is in favour of conservation of ecosystem services in developing countries, and where the adoption of PPP would impose costs on poorer landowners rather than on better-of beneficiaries (Wertz-Kanounnikoff 2006; Pagiola et al. 2005).

2.1.4 Payments for watershed services

As discussed above, PES is comparatively an effective, flexible and cost efficient mechanism than any other conservation approaches. It can be implemented where the application of other government policies would be impossible due to socioeconomic or political aspects. Furthermore, PES mechanism fulfills ecosystem conservation and poverty reduction goals. Among the vast services ecosystems provide, four most common services with ongoing payment programmes are carbon sequestration and storage, biodiversity protection, watershed protection, and landscape beauty (Wunder 2005; Wunder et al. 2005). The scale on which the four sorts of ecosystem services are perceived differs (Table 2-4). Carbon sequestration and storage and biodiversity protection are the greatest concern at global level, while landscape beauty and watershed protection are primarily local to national concerns.

Table 2-4: Scale of influences of four ecosystem services

Scale	Carbon sequestration and storage	Biodiversity protection	Landscape beauty	Watershed protection
Local rural community	0	++	++	+++
Provincial/ district public & policymakers	+	+	++	+++
National public & policymakers	+	+	+	+++
Global public & policymakers	+++	+++	0	++

Notes: +++ Very important; ++ Important; + Some significance; 0 Not a direct concern

Source: Jeanes et al. (2006)

In this thesis, particular attention is given to watershed protection. Watersheds provide several services, which are products of ecosystem processes. Landell-Mills and Porras (2002), and Mayrand and Paquin (2004) defined five services delivered at the watershed level. These were water flow regulation, water quality maintenance, erosion and sedimentation control, land salinisation reduction, and maintenance of aquatic habitats. Tomich et al. (2004) remarked that a peak in public interest regarding watershed always happened on five controversial issues, which were on-site effects of soil erosion, off-site effects of soil transfer, flooding, seasonal drought, and water pollution. Of the five points, pollution from land use was the greatest concern on every scale. In short, watershed services are ecosystem services provided by a watershed. These services provide benefits downstream, typically in the form of water quantity and water quality, which are obviously influenced by upstream land use and farming practices.

A growth of payment for watershed service (PWS) is necessary due to the fact that demand for clean water is rising and conventional policies may not be compatible with privately owned land. Landell-Mills and Porras (2002) identified 287 PES initiatives, of which 61 cases were for watershed services, applied in 22 countries. Hope et al. (2007) revealed that global interest in the arrangement of PWS was growing as demonstrated by the number of projects jumping to over 100 by 2005. The success for applying PES approaches depends on many factors. Past experiences revealed that the overall chances of negotiated reward mechanisms have relied on (Engel et al. 2008; Jeanes et al. 2006):

- how shared perception regarding ecosystem functions shapes the interests of stakeholders;
- the extent the trade-offs between providers and buyers affect ecosystem functions;

- in what way the existing local institutions restrict decision-making of individuals; and
- by what method confidence among stakeholders works to reach agreement.

In the following sections, there is a review of the dimensions and general characteristics of PWS programmes.

2.1.4.1 Commodities in the context of payment for watershed services

The transformation of ecosystem services into commodities that can be sold in the market is one of the challenges in establishing PES programmes (Mayrand and Paquin 2004; Landell-Mills and Porras 2002). A precise service is a prerequisite in defining a commodity since each potential beneficiary has a different perception and views regarding needs and values of service. Demand for watershed services should be clearly defined and understood in the same way. The question of 'who demands what?' must be thoroughly answered. For example, local residents always request standardised water quality, while downstream ecosystems requires enough water to maintain their functions.

Watershed services can be translated into tradable commodities as shown in Table 2-5. IIED (2004) suggests a tradable commodity should have at least three features. Firstly, it must be tangible. Secondly, it must be included in making any judgment, and finally it is preferably based on sound science[5]. Watershed services typically fall into five categories which are water quality, water table regulation, water quality and regulation, soil contaminant control, and aquatic habitat protection. Each service can be translated into several types of commodity. Water quality, for example, can be transformed into four commodities that are best management practice contracts, water quality credits, land acquisition, and conservation easements.

[5] Tomich et al. (2004) reveal that most of economic valuation of watershed functions depends on the studies of soil scientists, hydrologists or physical geographers

Table 2-5: Converting watershed services into commodities

Watershed service	Commodity	Description
Water quality	Designed contract	A contract agreed among service providers and downstream beneficiaries in setting series of 'best management practice' for a specific purpose. Landholders must confirm the contract in return for set payment.
	Water quality credit	Point source polluters are allowed for excessive release of pollution as long as they invest in nonpoint source pollution reduction
	Land acquisitions	A purchase of land where ecosystem services are available. By this method, land tenures are totally transferred from one to another.
	Conservation easement	A contract between landholders and whoever wants to protect natural ecosystems in a particular area. Landholders are paid to manage their land corresponding to the conservation objectives.
	Pollution permit	An agreement to set upper limit for pollution released from point source pollution, and polluters who discharge less than their quotas can trade the rests to others.
Water table regulation	Salinity credits	Salinity emission limits are traded, while tree planting campaign is promoted in critical areas where salinity of surface soil and water body is a major problem.
	Transpiration credits	Similar to salinity credit, but the evapotranspiration and water table are the two main concerns.
	Salinity-friendly products	Payments for salinity control services are added into existing products.
	Stream flow reduction licenses	A tradable permit for land-based activities reducing water supply for downstream users. Landholders who can decrease their stream flow reduction can sell an excess license to the others.
Water quality and regulation	Watershed protection contracts	Contract negotiated between watershed landholder and downstream beneficiaries that specifies watershed management activities that will be undertaken in return for set payments.
	Protected area	A defined boundary promoted as an ecosystem protection and maintenance area. It is normally managed through legal or other effective means.
	Land acquisition	A purchase of land where ecosystem services are available. By this method, land tenures are totally transferred from one to another.
	Water rights	An endowment of property rights upon water use.
	Watershed lease	Lands in watershed are leased by downstream beneficiaries to carry out watershed protection activities.

Watershed service	Commodity	Description
Soil contamination control	Ecolotree planting	Plantation and vegetation systems that filter and absorb contaminated water from soil.
Aquatic habitat protection	Designed contract	A contract agreed among service providers and downstream beneficiaries in setting series of ‘best management practice’ for a specific purpose. Landholders must confirm the contract in return for set payment.
	Land leases	The rights to protect and conserve the resources are transferred from government to whoever devotes for natural ecosystem protections. Government will receive an up-front payment and annual fees in return.
	Salmon safe products	Landholders who comply with arranged management practices regarding salmon sensitive land management obtain a financial reward in terms of cap on existing products.
	Salmon habitat restoration contracts	A designed contract aims to protect salmon habitats. Those who provide a service get set payments in return.
	Salmon habitat credits	A system requires that landholders in salmon sensitive-prone area, such as riparian buffer, must develop the habitat as long as they balance this by purchasing habitat credits in more valuable habitat zones.
	Water rights	An endowment of property rights upon water use.

Source: adapted from IIED (2004); Landell-Mills and Porras (2002)

2.1.4.2 Market for watershed services

Watershed services, like other ecosystem services, are not explicitly traded in markets. Therefore, their quantity and quality are neither regulated by the price mechanism, nor by demand and supply relationships. In order to set up a market for a watershed service, it is necessary as a first step to identify the service that will be in exchange, i.e. a clearly defined commodity. Plenty of services provided by water-related ecosystems are available; therefore, it is a vital process to match a particular service from ecosystems with a direct and demonstrable benefit to consumers (Powell and White 2001). In case of the market for watershed services, landholders or suppliers of the services will receive rewards and are encouraged to conserve, and protect watershed for producing valuable watershed services to beneficiaries or buyers of the services. Supplies of watershed service are quantity, quality and timing of water flows generated by upstream landholders, while demands for services are normally from downstream beneficiaries for a specific use, such as domestic use, hydropower plant, fisheries, and irrigation.

Landell – Mills and Porras (2002) report that demand, illustrated by the growing willingness to pay from both government and private authorities, is the main driver for establishing a market for watershed service. Supply-side driver, on the other hand, is typically not a major force because the characteristic of watershed that is not possible to exclude beneficiaries. However, it is the case if all beneficiaries are convinced of the threats to supply. The key for success in establishing markets is that the creation of market guarantees for the lowest transaction cost associated with that market. This is due to the fact that a market will work effectively when no other institutional arrangements exists with lower transaction costs (Whitten et al. 2003; Davidson and Weersink 1998).

2.1.4.3 Payment mechanism

In the market for watershed services, a service providing a positive externality from providers will happen only if there is reasonable compensation from potential beneficiaries. Payment mechanisms in the market for watershed services have various forms. Eight categories of payment mechanisms are identified for watershed services (IIED 2004; Landell-Mills and Porras 2002):

1. Direct negotiation: this is probably the most direct payment method arranged between service providers and beneficiaries. The method is popularly applied with best management practice contracts.

2. Intermediary-based transaction: mediator such as trust fund, local or international NGOs, or government is involved to control transaction costs and risks.

3. Pooled transaction: this payment method is suitable when investors are interested in different commodities. The mechanism will spread risks amongst several buyers.

4. Retail based trade: certifications or labelling schemes are required for putting additional price onto existing consumer purchase. This mechanism is mostly applied with salinity-friendly product and salmon safe product.

5. Over-the-counter trade and user fee: this mechanism is available with commodity pre-packaged for sale such as water quality credit. Watershed services are offered at a standard rate for different users through user fees.

6. Clearing-house transaction: this is rather a new mechanism deployed greatly in developed countries, and still in its introduction stage. An intermediary proposes a central trading platform for both buyers and seller. By this method, government must enact and enforce regulations to smooth the transactions.

7. Internal trading: transactions are taken within an organisation. By this way, organisations will internally perceive their willingness to pay before making decision for further external trading.

8. Auction: this method is like clearing-house and over-the-counter trading mechanisms. The method allows for an establishing of competitive market where supply of and demand for watershed services are played on the same ground.

Global experience suggests that PWS as a market-based instrument can be introduced to tackle water pollution. A mutual commitment between upstream service providers and downstream users is a key factor driving a sustainable programme. So far, the practice of the payment programmes varies from place to place with controversial issues regarding degrees of government involvement. The next section presents a review of PWS by investigating current commodities, potential market drivers, and payment mechanisms, and comparing the differences of programmes between developed and developing countries in a quantitative review.

2.1.5 A review of payment for watershed service studies

A review in this section is based on the concept of meta-analysis, which is a statistical procedure that integrates the results of several independent studies considered to be combinable. The advantage of meta-analysis is that it allows a more objective appraisal of the evidence than narrative reviews (Egger et al. 1997). This section aims to integrate data and understand common characteristics of PWS prevailing in developed and developing countries. To do this, literature searches were conducted during January 2007 on numerous databases, such as bibliographic databases, subject gateways and other internet resources. 70 PWS programmes, representing 47 cases in developing countries and 23 cases in developed countries, were selected (Annex 1). Results from the analysis are presented as follows.

2.1.5.1 Current commodities in exchange

In developing countries, the most popular traded commodity was a re-allocation of the right to regulate natural resources (i.e. water quality), which was as high as 40% of all transactions (Table 2-6). Right re-allocation was typically taken the form of a claim on water-related resources from a government authority charging a direct fee from users, such as hydropower plants, industries, or domestic water users.

Table 2-6: Current traded commodities

Commodities	**Developing countries**		**Developed countries**	
	Frequency	**%**	**Frequency**	**%**
Designed contract	15	22.7	12	18.2
Credit scheme	-	-	5	7.6
Ecolabel product	3	4.5	1	1.5
Transfer of land tenure	2	3.0	2	3.0
Emission trade	1	1.5	6	9.1
Re-allocation of the right to regulate resources	26	39.4	-	-
Scientific proof	-	-	2	3.0
Trade of water rights	3	4.5	-	-
Voluntarily extra payment	2	3.0	-	-

Note: more than one type of commodity can be traded within a programme

Designed contracts, such as BMPs and a restoration contract, were prevalent in both developing and developed countries. More complicated products, such as credit schemes, emission trades, and scientific proof[6] were apparently seen in developed countries.

2.1.5.2 Market drivers

Generally, a government authority was the key driver for establishing a market for watershed services. In developing countries, the frequency of solely a government authority acting as the market driver was as high as 55% (Table 2-7). A few cases showed that a market was established by cooperation between a government authority and other agencies, such as NGOs, multilateral organizations, and local communities. In developed countries, besides government enforcement, pressures from private agencies also activated the market. Examples were Vittel mineral bottled water company in France, Stadtwerke München in Germany, and Ecolotree in the United States. Driving forces from communities were seemingly rare, and mostly arose in developing countries mainly in the form of a beneficiary-collective group, such as farmer associations.

Table 2-7: Market drivers for PWS programme

Market drivers	Developing countries		Developed countries	
	Frequency	%	Frequency	%
Government authority	36	54.5	15	22.7
Government authority and NGOs	1	1.5	1	1.5
Government authority and multilateral organisation	1	1.5	-	-
Government authority and community	1	1.5	2	3.0
Community	3	4.5	-	-
Community and NGO	2	3.0	-	-
Private concerned agency	2	3.0	5	7.6
Government authority and NGOs and Private agency	1	1.5	-	-

Note: more than one type of market driver can be seen within a programme

[6] This type of commodity is supported by sound science evidences to illustrate how ecosystem services could be improved by the adoption of such commodity. An example is Ecolotree planting providing a soil contaminant control. The research showed that the adoption of Ecolotree planting can minimise contaminant in soil with the technique of photoremediation.

2.1.5.3 Payment mechanism

The PWS programme can have several possible payment methods depending on the characteristics of buyers and sellers, commodity attributes, and roles of stakeholders within a specific watershed. In both developing and developed countries, intermediary-based transactions were a dominant mechanism (Table 2-8). Mediators were introduced to the programme so as to manage and eliminate risks, uncertainties, and transaction costs. Intermediary-based transactions can be taken by a government authority, trust funds, NGOs, communities or even private companies.

Table 2-8: Potential payment mechanisms

Payment mechanisms	Developing countries		Developed countries	
	Frequency	%	Frequency	%
Direct negotiation	6	9.1	3	4.5
Intermediaries-based	43	65.2	15	22.7
Pooled-transaction	9	13.6	1	1.5
Retail-based	-	-	1	1.5
Over the counter/ user fee	11	16.7	2	3.0
Clearing house	-	-	4	6.1
Internal trading	2	3.0	-	-
Auction	-	-	3	4.5
Ecological ICMS	1	1.5	-	-

Note: more than one type of payment mechanism can be available within a programme

The most popular form was the government-intermediary based transaction, which was as high as 70% in developing countries and 87% in developed countries (Figure 2-6). This was followed by NGOs-based and trust fund-based transactions. A trust fund-based transaction is a trust fund to finance payment by establishing pooled-demands for watershed service amongst various beneficiaries (Postel and Thompson 2005). The occurrences of community-based transactions were rare in developed countries.

Besides the aforementioned mechanisms, a case in the State of Paraná, Brazil offers an example of payment mechanism which is explicitly different from other PWS programmes. The state government allocated transfer payments to municipalities with more water reserves, conservation units or protected areas. The financial payment was funded by ‘Ecological ICMS’ (an indirect tax charged on consumption of goods and services) to encourage and promote watershed and biodiversity rehabilitation. The system has been called a ‘redistribution mechanism’.

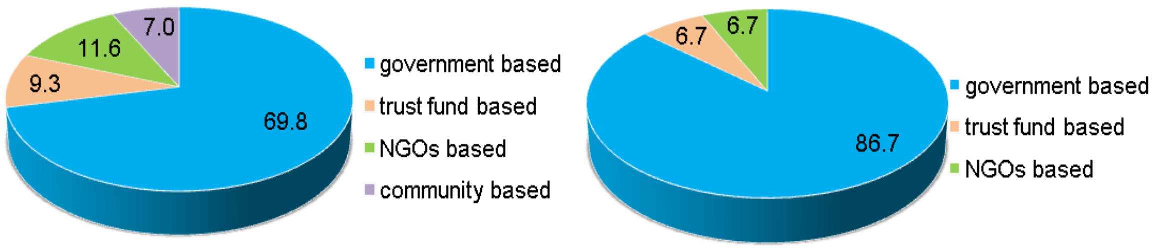

Figure 2-6: Types of intermediary-based transaction in developing countries (left) and developed countries (right) (%)

Overall, the concept of PWS can be used to control agricultural nonpoint source pollution as it offers a shared benefit between stakeholders in a specific watershed, and ensures acceptable standards in water bodies by source control techniques. PWS also has a superior characteristic compared to other pollution control approaches in that it is a tailored-contract matching local conditions. It has a characteristic of decentralised policy which contributes to an improvement of service provision by making it more responsive to the people being served. Accordingly, the market for PWS is growing and there is increasing interest as water becomes scarce and the effects of water pollution are impacting human health and environment.

2.1.6 A review of best management practices

Land is an important input in agriculture, and private property right, either *de facto* or *de jure* right, is normally granted to farmers. Agricultural land provides food and fibre, and supplies ecosystem services (i.e. changes in agricultural practices, such as BMP adoption, can contribute to improved water quality) (Millennium Ecosystem Assessment 2005). As an improvement in an ecosystem services is often produced as a by-product of private productions, users and beneficiaries who consume and enjoy this benefit stream do not pay for it. If a government promulgates policies requiring BMPs to control farm pollution, this adds external costs in farm production. Based on private decisions, farmers may not want to adopt BMPs because of low profits, uncertain returns, or length of time to realise the benefits. However, a growing awareness of agricultural nonpoint source pollution in developed countries, such as the United States and the United Kingdom, has led to the establishment of ‘designed contracts’ to compensate farmers for the generation of positive externalities.

The United States enacted the Clean Water Act of 1972, which is the national policy for the control of nonpoint source pollution. The Act introduced BMPs as a measure to manage water pollution at watershed level (US EPA 2003). The US EPA (2010) classifies agricultural BMPs as the most effective and practicable (including technological, economic, and institutional considerations) means of controlling agricultural nonpoint pollutants at levels compatible with environmental objectives. BMPs are defined as management practices controlling the generation and pollutants into water resources or remediating or intercepting pollutants before they enter watercourses (US EPA 2003). The implementation of BMPs is undertaken by the US EPA.

Recognising that agricultural nonpoint source pollution is mainly from mismanagement and misuse of land inducing erosion, nutrient and pesticide, US EPA encourages farmers to adopt a series of good practices and to reduce or eliminate poor practices. BMPs can be implemented in the form of both management incentives and management practices (Centner et al. 1999). The management incentives are procedural practices, which conform to good husbandry. Examples are the use of optimal rate of fertiliser at the right time, and the adoption of pesticide spraying techniques that prevent spray drift into watercourse. The management practices are divided into vegetative and structural practices. Vegetative practices are measures controlling erosion and run-off from the field, while structural practices are permanent barriers or buffers generated through construction or site modification. All measurements can be applied before, during, and after pollution-producing activities (Brown et al. 2007).

Similarly, the Water Framework Directive established in 2000 sets a timetable for the next 27 years to protect, improve, and sustain water use in EU countries (Collins 2004). The Directive has been transposed into the UK law, where the Department for Environment, Food and Rural Affairs (Defra) acts as a leader for the implementation in England and Wales. The Scottish Environment Protection Agency is responsible for that in Scotland. Codes of Good Agricultural Practice are set out to provide an important point of reference for farm operations. Under the Codes, good agricultural practice means a practice that minimises the risk of causing pollution while protecting natural resources and allowing economic agriculture to continue (Defra 2003: 3). The Codes advise that farmers should acknowledge causes and effects of pollution as a result of poor agricultural practices, and they should know how to operate in sustainable ways, and what to do in an emergency.

With an increase in awareness over water pollution, one particular concern is that the UK might need to learn from the United States and elsewhere on developing best management agricultural practices (D'Arcy and Frost 2001; D'Arcy et al. 1998). Accordingly, Defra introduced a user manual called ‘An Inventory of Measures to Control Diffuse Water Pollution from Agriculture’ (Cuttle et al. 2007). The manual lists forty four measures for controlling nonpoint source pollution, especially nitrate, phosphorous, and faecal indicator organisms as a consequence of agricultural activities, such as land use, soil management, livestock management, and fertiliser management. It also identifies the effectiveness of each of the measures. In general, the UK Codes aim to elevate pollution prevention activity for each type of land use by the adoption of good practices and mutual agreements between farmers and government.

A considerable amount of public budgets spent on agri-environmetnal programmes raises concerns about the environmental benefits and effectiveness of the proposed good practices (Schönhart et al. 2010). As such, an integrated model determining the links between ecology (i.e. characteristics, process and functioning) and economics (i.e. demand for goods and services supplied by ecosystem) is required. The challenge for policymakers is to bring economists to work closely with natural scientists to build understanding of ecological production functions from farms and to apply appropriate valuation exercises (Polasky 2008).

To simulate major processes in agricultural land use management, bio-physical model is a tool to understand and predict the environmental performance of alternative farming practices (Daily and Matson 2008). A variety of models can be used to simulate the effectiveness of BMPs at numerous scales, such as field- and watershed- levels. For example, Vinten et al. (2004) adopted three alternative approaches (i.e. a soil transport model, a regression using observed E. coli concentrations in surface water, and PAMIMO model) to predict delivery of faecal indicators from dairy farms to surface water in river

Irvine catchment. McGechan et al. (2008) used the combined model (i.e. MACRO hydrological model and a channel network model) to define transport of ammonium and E.coli form dairy farms and simulate contaminant delivery to rivers. Rao et al. (2009) employed a variable source loading function to simulate the impact of BMPs in P load reduction from the watershed. Nendel (2009) adopted an EU-Rotate_N model to compare a traditional fertiliser strategy with the recommended practices and found that the BMP adoption resulted in lower N leaching.

Iovanna and Newbold (2007) argued that an assessment that could reflect ecological complexity, such as ecological process and ecological-economic interactions, can lead to better policy outcomes by increasing resilience. The outputs from bio-physical models generate inputs for economic valuations, such as Cost Benefit Analysis (CBA) and Cost Effectiveness Analysis (CEA) (Zhou et al. 2009). CBA is an approach to compare the desirability of alternative investments by representing all values (i.e. costs and benefits from BMP adoption) in monetary term. For CBA, the results from a bio-physical model could benefit an economic valuation in that ecological dynamics, uncertainties and irreversibilities are accounted for in a policy evaluation. In other words, a model predicts a potential environmental improvement which affects human well-being. This environmental improvement has its own economic values, which can then be measured under the concept of Total Economic Value (TEV). On the other hand, CEA is an approach to compare the relative costs and outcomes of options. The least cost method, given an environmental target, is chosen. A bio-physical model benefits a CEA in that it estimates the impacts from new farming practices; thereby determining environmental benefits which in turn are effectiveness sides of BMP. Overall, a bio-physical model provides scientific information about the usefulness of BMPs, and when integrated with an economic valuation it could be used to address ecological sustainability in an agri-environmental policy assessment.

As the discussion above attests, the impacts of water pollution caused by agricultural pollutants are immense and result in the steady degradation of watershed ecosystems. Global experience suggests that on-farm BMPs, as a PWS programme, could control nonpoint source pollution. Tackling nonpoint source water pollution requires a good understanding of its nature and characteristics, and the effectiveness of BMPs. In the promotion and marketing of BMPs, a crucial assumption is that behaviours are rational as understood early in a rationality context, particularly the neoclassical theory of profit maximisation. However, behaviours are not homogeneous, and needed to be explored further (Leiser and Azar 2008; Spash and Biel 2002; van den Bergh et al. 2000). Accordingly, this thesis deals with this challenge by employing a supplementary of social psychology theory to capture more complex behaviours of human.

2.2 Review of Methodologies

This section aims to review the methodologies and rationale of applications that are employed in this thesis. The review begins with a discussion of the notion that cost is the main barrier to the adoption of new conservation practices. It then proceeds to a discussion regarding farmers' decision-making, which is typically assumed to be rational, and points to a gap in underlying assumptions between neoclassical economics and psychology in relation to behavioural responses. This suggests a need to incorporate a social psychology theory into the study of adoption behaviour, so as to capture complex aspects of farmers.

2.2.1 Factors influencing farmer's decision-making

Traditional neoclassical economics assumes that farmers are profit maximisers, who are rational and behave in a way to maximise their utilities. Adoption behaviours are normally explained by the complexity of the social aspects of farm households, such as economic variables, and biological and physical variables within one objective function. In the traditional view, previous work suggests that many factors constrain the adoption of conservation practices, but the most frequently mentioned barrier to adoption is cost (Rodriguez et al. 2009).

In the context of water pollution from agricultural land, the introduction of conservation practices, such as BMPs is expected to reduce negative externalities by controlling pollutant discharge. Wieland et al. (2009) argued that the true cost of reducing farm pollution from surface water is the payment for implementing qualified BMPs, not for directly reducing nonpoint source pollutant. At farm level, farmers are decision makers who bear substantial financial responsibility for any conservation practice being implemented on their land. The adoption of conservation practices is often characterised by high up-front costs, which could deter farmers' adoption (Pannell et al. 2006). Thus, knowledge about costs is critical given the limited resources available on farm.

A few studies investigated the cost of BMP implementation. For example, Sample et al. (2003) studied costs in the adoption of stormwater BMPs. The major costs considered included the initial capital costs and the present value of annual operation and maintenance costs that were incurred over time. Cubbage (2004) estimated the cost to comply with forestry BMPs and found that BMP costs per area were often highest on steep terrain. He further concluded that BMP costs increased over time as the standards and requirements become higher. Afari-Sefa et al. (2008) conducted a cost estimate for structural BMPs in farms. Their study provided insights into the magnitude and structure of on-farm costs to establish and maintain particular BMPs.

Overall, the ultimate aim of BMP cost analysis is to guide regulators about how to allocate public resources in order to encourage BMP adoption (Afari-Sefa et al. 2008; Wossink and Osmond 2002). Given the importance of cost analysis in agriculture, and the increasing importance of, and interest in, agricultural BMPs, a good understanding of cost can provide basic parameters for potential agri-environmental policy. This is the case in Thailand where there is limited empirical data relating to the cost of conservation practices, particularly BMPs recommended for citrus farms.

Apart from the cost of adoption, farmers' behaviour is thought to be the consequence of a complex integration between socio-economic and psychological variables. Accordingly, the decision-making process of farmers could not be merely modelled by mathematical methods traditionally used by agricultural economists (Willock et al. 1999), and the rational man assumption for environmental policy may not be pertinent (Shogren and Taylor 2008). To a degree, several analytical approaches have been applied to agricultural economics to investigate farmers' responses to policy initiatives (Burton 2004). A considerable amount of research has been conducted to understand the process of farmers' decision-making and the question of which factors influence adoption of agri-environmental policy. Kaiser et al. (1999) suggested that two-thirds of all environmental-psychology publications include the notion of environmental attitudes in one form or another. Previous studies revealed that an inclusion of psychological variables into the adoption model of agri-environment schemes enables more predictive power (Edwards-Jones et al. 1998). Further, farmers' segmentation based on their attitudes allows introducing the right policy to the right farmers (Sutton 1998).

In principle, neoclassical economics and psychology theory of attitude formation rest on relatively different assumptions regarding adoption decisions. Table 2-9 shows some major differences between economics and psychology. In the neoclassical paradigm, one common interpretation is that people have well-defined preference rankings, which can be discovered by examining evidence on choices and the principle of revealed preference. These rankings are then taken as the basis for welfare evaluations. In other words, neoclassical economics assumes rational human behaviour. The individual thinks logically about choices by using all available information and allowing for the effects that current choices will have on future choices and future outcomes. In contrast, the alternative theory of non-rational behaviour is based on psychological hypotheses, which postulate that behaviour is determined by many factors besides the simple economic contingencies.

The literature on farm decision-making has increasingly recognised the diversity and complexity of farmers' values, goals and objectives (Garforth and Rehman 2005). Smith (2005) argued that when people make choices that contradict with formal theory of rationality, this gives an opportunity to investigate: i) why they perform those decisions; and ii) how decision-making is processed and implemented. In practice, the economic model and cognitive model are complementary. A good understanding of pertinent psychological and neural processes is helpful in behaviour observation and can produce a more reliably predicted behaviour (Smith 2005). Studies to understand individual behaviour towards environmental concerns should equally combine cognitive variables and socio-economic determinants (van Liere and Dunlap 1980). According to van Raaij (1981: 6), 'a better integration of psychological variables in economic science will be reached when both economic and psychological variables are entered into a model, hypothesis, or theory'. The following section offers a discussion of the roles of social psychological theory in the study of adoption behaviour.

Table 2-9: Differences in assumptions between the economic model and psychological model

Assumptions	Economics	Psychology
Reference level	Each individual has stable and coherent preferences. Given a set of options and probabilistic beliefs, a person is assumed to maximise the expected utility of a chance.	A person's preferences are often determined by changes in outcome relative to his reference level, known as the status quo. For example, people dislike losses significantly more than gains.
Social preference	People deem to base on maximal-benefits criterion when making allocation.	Many people feel that goods should be allocated according to the maximin criterion. That is, social preferences over other people's consumption depend on the behaviour, motivations, and intentions of those other people.
Biases in judgement	When faced with uncertainty, people form their subjective probabilistic assessments according to the laws of probability.	People rely on heuristic principles which reduce the complex tasks of assessing probabilities and predicting values to simpler judgement operations.
Reciprocity and attribution	People's propensity to engage in any behaviour is primarily determined by whether or not it is in their financial interest.	People determine their personality/ behaviour toward others according to motives attributed to these others, not solely according to actions taken.
Misperceived utilities	Each individual always selects the most preferred option from the feasible set.	People do not always accurately predict their own future preference, nor even accurately assess their experienced well-being from past choices.
Preference reversal	People occupy the same preference, though there might be difference in the elicitation procedure.	People prefer different choices in different circumstances. That is, the presentation of a choice may draw our attention to different aspects of a problem.
Time-variant preference	Economists model people's tastes by assuming the people discount stream of utility over time exponentially. In other words, an individual's intertemporal preferences are time-consistent.	Psychologists believe that an individual's short term tendency to pursue immediate gratification is inconsistent with the long term preference.

Sources: Smith (2005); Kurz (2002); Rabin (1998); Tversky and Kahenman (1986)

2.2.2 Roles of social psychological theories

This thesis introduces the Theory of Planned Behaviour (TPB) and Q-Methodology to understand human behaviours. As discussed above, the inclusion of social psychological theories is useful to look beyond the rational economic assumption. It is expected that the integration of social psychological concepts can better explain human behaviours by informing and improving the understanding of farmers' decision process and attitudes towards BMP adoption. The following sections offer a discussion regarding the development of social psychology theory in the context of environmental behaviour.

2.2.2.1 Theory of Planned Behaviour

In agricultural economics, the most common feature to elicit farmers' objectives is the use of self-report questionnaires (Garforth and Rehman 2005). In the mid 1970s, the Theory of Reasoned Action (TRA) is a first model reliably demonstrating a link between attitudes and behaviour. TRA assumed that the most important determinant to predict actual behaviours is behavioural intention. The intention to perform is a combination of attitudes towards such behaviour, and subjective norms. The TRA assumption is limited when an individual perceives their ability to successfully carry out a behaviour to be low, and when a behaviour is not under full volitional control (Burton 2004). As a consequence, the Theory of Planned Behaviour (TPB) was added to the TRA model to address this inadequacy by adding a third element, known as perceived behavioural controls. The principle of TPB is incorporated into the economic framework of decisions and behaviour in order to explain and predict complexity of farm decision-making. TPB is applicable when studied behaviour is voluntary and not bounded by prior commitment, and where deliberated thought about performing choice is involved (East 1993).

Beedell and Rehman (2000) highlighted that research work in the domain of adoption behaviour has moved from descriptive to predictive models in order to response to policy implementation. A number of studies have applied TPB to assess significant psychological factors in farmers' decision-making processes. For example, Rehman et al. (2007) developed questionnaires with psychological constructs to predict farmers' intentions to adopt new technologies on dairy farms. Hattam (2006) applied TPB to investigate psychological barriers to the adoption of organic production in Mexico. Fielding et al. (2005) used TPB as a framework to understand the extent to which beliefs influenced decisions to develop riparian zone management on farm, and van Gossum et al. (2005) applied TPB to identify who encouraged farmers to adopt government policy of multifunctional forest management. In Thailand, TPB has been applied in information technology adoption (Kripanont 2007; Tetiwat and Huff 2003), clinical research (Saengcharoen et al. 2008), and recycling behaviour (Chaisamrej and Zimmerman 2007). This suggests that the application of TPB in the context of agricultural policies in Thailand is relatively new, and the behavioural study based on TPB could provide insights into psychological factors facilitating BMP adoption.

TPB provides predictive advantages when modelling farmers' behaviour in responding to policy change. Firstly, TPB provides an understanding between attitudes and behaviour through the incorporation of additional variables from social psychology. This allows an analysis based on individual perspectives. Secondly, TPB suggests beliefs and attitudes influencing behaviour, and at the same time it determines the relative importance of those factors. Thirdly, it combines both qualitative and quantitative analyses to understand, and predict potential behaviour (Ajzen 1991). Lastly, TPB can offer policymakers the potential to design a more targeted intervention to induce a desirable behaviour. This combination of approaches lends depth and clarity to address decision-making related issues.

2.2.2.2 Q-Methodology

An application of social-psychology methods to improve understanding of farmers' decision-making is widespread (Garforth and Rehman 2005). Of many methods, Q-Methodology is applied to uncover different patterns of thought, and better understand the concerns of farmers in relation to an adoption of conservation practices. Q-Methodology is a technique for studying human subjectivity (Stephenson 1953). Originating in psychology research, the method has now been used in other disciplines including the fields of communication, political sciences, health sciences, and more recently, in ecological and environmental studies. Empirical studies show that there are no universally significant factors affecting adoption of conservation agriculture, and a targeted policy approach should be designed to the particulars of a locale, or preferably, to individual farmers and their farm operations (Knowler and Bradshaw 2007). Q-Methodology is applied in this thesis to segment farmers based on their salient attitudes towards BMP adoption, and to investigate different attitudinal variables influencing different groups, or subgroups, of farmers.

Evidence from Q-Methodology is increasingly being used to inform policy decisions. Hall (2008) investigated farmers' attitude towards Genetically Modified crops cultivation in Scotland. Davies and Hodge (2007) employed Q-Methodology to investigate the perceptual frameworks of a sample of UK arable and mixed lowland farmers regarding the appropriate way in which to approach the environmental management of agricultural land. Further applications have been undertaken by Barnes et al. (2007) who investigated farmer attitudes to Nitrate Vulnerable Zone regulation. Brodt et al. (2004) considered the adoption of biologically integrated agricultural practices from the perspective of almond and wine grape farmers. Ellis et al. (2007) explored the nature of public acceptance of wind farms in Northern Ireland, and Kramer et al. (2003) focused on the reasons why some dairy producers in Uruguay had not participated in a registry system. In Thailand, the application of Q-Methodology has been recently introduced in relation to policy perspectives of an epidemic disease (Brown and Wattanakul 2008).

Q-Methodology offers several methodological advantages over other predictive multivariate analysis of behaviour or adoption. The first is that Q-Methodology is self-referent, and does not require pre-defined attitudinal variables. Rather it draws directly on discourses from the population studied, hence it lessens the extent of researchers' bias (Barnes et al. 2007). Secondly, the use of factor analysis in Q-Methodology relies on different approaches to the typical R-Methodology use of factor analysis[7]. In Q-Methodology participants are the variables. They are correlated with each other to produce factors linking those who have similar attitudinal perspectives. In contrast, R-Methodology provides analysis based on differences amongst all participants for each variable, such as age and gender, and there is no interaction between participants (Steelman and Maguire 1999; Fairweather et al. 1998). The different philosophy in Q-Methodology provides an alternative lens through which to reveal preferences, values, and interests underlying the participants' understanding of the research topic (Brown et al. 2008; Durning and Brown 2006). Lastly, a series of Q methodological steps comprise both quantitative and qualitative approaches. The combination of numerical analysis and qualitative interpretation combines statistical significance to clarity of attitudes (Barry and Proops 2000), and thereby increasing the level of research reliability and validity (Silverman 2006; Furlong et al. 2000).

[7] R-Methodology is a typical factor analysis method, where researchers look for correlations amongst variables (i.e. personal traits such as age, gender, education, etc.) across a set of people.

2.3 Summary

The above discussion highlights a number of salient issues that need to be kept in mind as this thesis evolves. At a global scale, nonpoint source pollution from agricultural activities stands as the primary cause of water quality problems. It is one of the most complex environmental problems and its impacts are extensive. The pollutant discharge results in degraded water quality, and preventive measures are needed to intercept pollutants before reaching water bodies. As sources of agricultural pollution are difficult to identify, it cannot be easily controlled by government regulation and monitoring. Experience in developed countries showed that control of pollution at its source is considered the best strategy for managing nonpoint source pollution. One option is to introduce BMPs for controlling agricultural pollution at a watershed level.

However, in the development and promotion of BMPs it is assumed that farmers are homogeneous in goals and preferences, and it is suggested that behavioural theory may offer an alternative approach to investigate adoption reasons and behaviours. It is, therefore, essential to understand the adoption process beyond the purely economic-based model of farmer decision-making. Instead, BMP uptake should be perceived as a human behavioural issue, and the TPB and Q-Methodology are suggested by this thesis to supplement the economic model of adoption behaviour. The TPB is useful to explain adoption intentions, and to identify factors that will influence farmers to implement BMPs. Q-Methodology identifies different attitudes towards BMP adoption, segments farmers, and indicates which farmers are willing to adopt BMPs.

The next chapter presents the costs of twelve BMPs that are proposed for citrus farms in the Ping river basin. Given the fact that cost is one barrier in the adoption of new technology, information about these costs gives a basic overview of compliance costs incurred by farmers. This information would then be useful in the design of water-related PES programme, i.e. levels of incentive to induce farmers’ participation.

3 FARM-LEVEL COST ANALYSIS

Cost is usually thought to be the main barrier to the adoption of new conservation practices. This chapter aims to investigate cost structures in citrus production, cost components in BMP installation and maintenance, and the magnitude of costs incurred by farmers. Its context is set out in Figure 3-1. Section 3.1 begins with a farm budget presenting fixed and variable costs in citrus production. Section 3.2 presents a description of BMP functionings, potential benefits from adoption and the effectiveness of BMPs. Section 3.3 presents the assumptions of costs categorisation and cost estimation for BMPs.

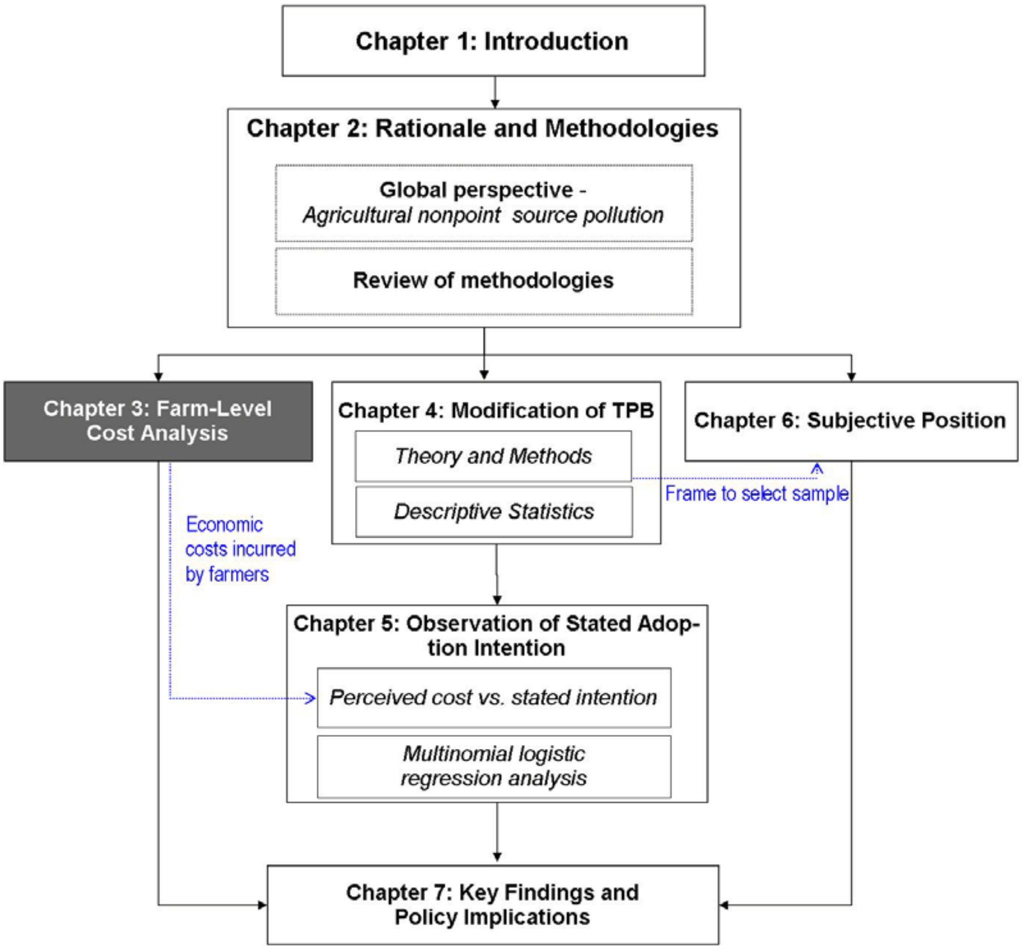

Figure 3-1: Thesis structure

In this section, the assessment represents an approximation of the costs that would be expected if BMPs were fully implemented. Calculated on the assumption that all practices are optimally sized and designed from an engineering point of view, BMP costs are divided into two components, which are installation and annual maintenance costs, and land opportunity cost. In section 3.4, to compare investment projects of unequal lifespans, annualised costs of all twelve BMPs are presented. Section 3.5 discusses the generalisation of these cost estimates and addresses the necessity of the cost study. This chapter closes with a summary of key findings in section 3.6.

3.1 Farm Budget of Citrus Production

Cost structure of citrus cultivation involves initial and annual costs. Initial costs are investment costs needed to set up the plantation, such as land preparation, furrow ploughings, irrigation system installation, seedlings, and labour hired for planting. These costs are unique to each farm. The most common classifications of annual costs are variable and fixed costs (Peris Moll and Julia Igual 2006; Julia Igual and Server Izquierdo 2000). In this thesis, the focus is on the annual cost of citrus production as this can provide basic information for an analysis of farm-level costs and the estimation of opportunity costs in relation to the BMP adoptions.

Variable costs are the costs that vary with yield within a production period, while fixed costs are those remaining the same within a production period and do not vary with the level of yield. In this study, annual budgets of costs and revenues for mature trees (i.e. the pay back period is after the third year) are estimated. Estimated costs are average costs from year 2002 to 2007, while estimated revenues are based on the average selling price from year 1984 to 2008 (Table 3-1). Variable costs include labour cost, input cost, and interest on working capital[8], while fixed costs include land rent, equipment ownership costs and interst expense.

[8] Julia Igual and Server Izquierdo (2000) argued that interest on working capital is an opportunity cost comprising the combined costs generated by factors of production invested during the production period, and which are used up in a single process. As it is a capital, it generates costs in the form of interest.

Table 3-1: Cost structure in citrus production

Descriptions	THB/ rai	%
Variable costs[1]		
1 Labour costs		
1.1 Weeding, pruning and spraying	5,157.4	31.8
1.2 Harvesting	2,848.8	17.5
2 Inputs		
2.1 Fertiliser and manure	2,863.0	17.6
2.2 Pesticide, herbicide and fungicide	1,784.0	11.0
2.3 Equipment operating costs (i.e. fuel and lubricants)	649.8	4.0
2.4 Machinery rental	526.3	3.2
2.5 Repairs and maintenance	112.0	0.7
3 Interest on working capital	1,045.6	6.4
***Total variable costs* (A)**	***14,986.7***	***92.3***
Fixed costs[2]		
4 Land rent	510.1	3.1
5 Equipment ownership costs (i.e. irrigation system depreciation)	677.9	4.2
6 Interest expenses	61.1	0.4
***Total fixed costs* (B)**	***1,249.0***	***7.7***
Total (C) = (A) + (B)	**16,235.7**	**100.0**
Average yields (kg/ rai)[3] (D)	6,500.0	
Selling price (THB/ kg)[4] (E)	15.1	
Revenue (F) = (D) x (E)	**98,215.0**	
Returns over variable costs (G) = (F) – (A)	**83,228.3**	
Net returns (H) = (F) - (C)	**81,979.3**	
Given there are 65 trees/ rai, then		
Returns/ tree = THB1,280.4		
Return/ sq.m. = THB53.0		

Sources:
(1) OAE (2007)
(2) OAE (2007)
(3) Farmers's interview: 100kg/ tree; 65 trees/ rai
(4) DOAE (2007b)

Note: The costs and revenues from citrus production are calculated for the pay-back period after the third year.

Variable cost is the most important cost in the production, and it is as high as 92.3% of the total costs. Within the variable cost category, labour cost on weeding, pruning and spraying has the highest share. This is followed by fertiliser and manure (17.6%), and labour cost for harvesting (17.5%). Fertiliser and manure represents the highest expenses within all the inputs used in the production. This information is similar to Namruengsri's study (2005) which revealed that approximately 20% of farm expenses are for fertiliser. The total variable cost is estimated at THB14,986.7/ rai. The fixed cost is related to fixed factors in citrus production, and it is estimated at THB1,249/ rai. The farm revenue is calculated by multiplying average yield per rai with average selling price, and this is equal to THB 98,215/ rai. The returns over variable costs remain THB 83,228.3/ rai, and the net return is THB 81,979.3/ rai.

3.2 Functions of BMPs

The Ping river is close to or passes through many of the major cities, including Chiang mai and Nakorn Sawan. Moreover, the Ping river is one of the four upstream tributaries flowing southwards to form the Chao Phraya river, located the largest alluvial plain. Accordingly, water management in the Ping river basin needs to address both freshwater quantity and quality. Twelve BMPs, providing flexibility to accommodate local needs and site specific conditions, were selected from expert judgement. The functions, environmental benefits and effectiveness of each BMP based on literature are presented. In some cases, there is no available research predicting the BMP effectiveness, and it is fully recognised that additional research is required to establish this study.

Scheduling water structure

The traditional method of flood irrigation is widely seen in the lowland of the Ping river basin. Farmers rely on the techniques including diking, polderisation and the use of raised-bed plots (Figure 3-2). Water flows between the main irrigation canal or river and the plots. Water intake and drainage can be done by gravity (i.e. through intake), or by pumping. Inside each polder, raised-bed plots lie in parallel with unlined ditches, in which water stagnates permanenetly. The raised-bed plots are normally 6m wide. The width of ditches is usually 1.5m, and the depth is approximately 1m. Irrigation sprayed from a small boat is commonly used in the raised-bed plantation.

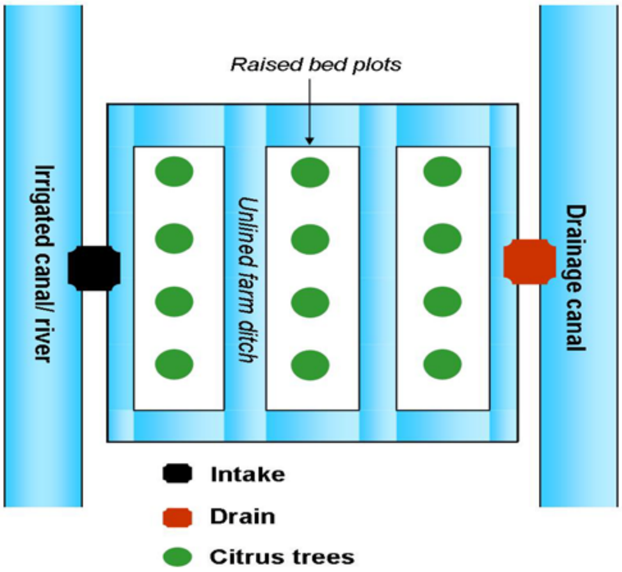

Figure 3-2: Irrigation system in the downstream area of the Ping river basin

This BMP requires farmers to check on the conditions of on-farm irrigation structure (i.e. intake, drain) and to maintain the farm ditches (i.e. bottom slope, ditch cleaning). The objective of this BMP is to ensure that the irrigation structure can properly function, and the ditches can provide additional storage and reduce the impacts associated with heavy rainfall (i.e. reduce sudden discharge) (Florida Department of Agricultre and Consumer 2004; US EPA 2000) . This BMP also provides habitats for a range of species if properly managed. The effectiveness of this BMP is site dependent (SEPA 2010).

Apply herbicide within tree canopy

According to the Florida Department of Agriculture and Consumer Services (2005), grassed soil beyond the canopy line can serve as filters and prevent sediment movement from the fields into the drainage systems. Excessive herbicide band width may result in considerable erosion of soil particles in particular during rainfall. The effectiveness of this BMP is site dependent (Florida Department of Agriculture and Consumer Services 2005).

Basic restrictions for pesticide application

BMP in the context of this discussion is to i) promote the proper handling of pesticides, fungicides and herbicides (i.e. storage); ii) improve application techniques (i.e. maintenance and calibration and protective clothing); and iii) record the use of chemicals (i.e. time and amount of application, type of chemicals used). The ultimate aims of this BMP are to gradually educate farmers on the danger of excessive/ improper use of chemicals, and raise awareness of responsibility in chemical application. The effectiveness of this BMP is site dependent (SEPA 2010).

Soil analysis

Namruengsri's study (2005) reveals that more than 20% of farm expenses are for chemical fertiliser and hormone, and approximately 50% of these expenses are unnecessary. The study shows that Thai farmers apply chemicals at the unnecessarily high rates only to maintain fruit appearance. The Florida Department of Agriculture and Consumer Services (2004) recommends a basic nutrient management with a consideration on soil, water, organic matter sample analysis and expected crop yields. Thus, this BMP mainly aims to manage the amount, source and timing of nutrient application, and then apply organic fertilisers to match with crops' needs. According to SEPA (2010), the effectiveness of this BMP is site dependent but it is remarkably effective in the management of dissolved N and P.

Vegetative cover

Both a row crop with drip irrigation and a row crop with mini-sprinkler system are widely seen in the upstream of the Ping river basin. The drip irrigation is done through drip tape or tube buried below the soil surface, and a pump is needed to provide the right pressure for water delivery into the pipe system. Similarly, with mini-sprinklers water is applied throughout the field by mini-sprinklers connected to a pressurised pipe system. Furrows between tree rows serve as both farm road and drainage during flash flood. The width of the furrows is approximately 6m.

This BMP requires a consistent bottom slope on furrows in order that a uniform vegetative cover can slow the overland flow, thus minimising the velocity of runoff and level of devastation of flash flood in hilly area especially during heavy rainfall. The primary aim of this BMP is to manage water discharge during rainfall events, but it also benefits in erosion control (Florida Department of Agriculture and Consumer Services 2004). Moreover, when the vegetative cover is densely planted this practice can control the growth of noxious weeds (USDA and Mississippi State University 1999). According to Schuster (1996), the amount of cover and the rate of infiltration are greatest under trees and shrubs. This is followed by, in decreasing order, bunchgrasses, shortgresses and bare ground.

Mulching

This BMP requires materials such as straw and grass to cover soil surface. The main objective of this BMP is to stabilise soil and control erosion by slowing the runoff and trapping sediment. Other benefits are to retain nutrients and moisture, slowly release nutrition, and assist germination (Florida Department of Agriculture and Consumer Services 2004). Sediment reduction by straw mulch without vegetation is 90-95% for a few months, and this gradually drops to 70% in six months. Nutrient reductions are estimated to be 60-80% for a very first month and reduce to 50% in six months (IDEQ 2005).

Vegetative buffer strip

Vegetative buffer strip is a sloping area of vegetative cover that filters pollutants before they reach the water body. In Thailand, a tropical plant known as Vetiver grass is extensively used to serve this purpose. Krutz et al. (2004) state that this practice potentially reduce herbicide transport from agricultural fields by increasing mass infiltration and adsorption, compared with bare soil. Other benefits from this BMP are to intercept sediments and reduce runoff velocity (Florida Department of Agriculture and Consumer Services 2004).

To function a water quality protection, the general recommended widths of buffer zone are 5 to 30 metres (Hawes and Smith 2005). The grass filter strip works best for sediment removal. According to Krumrine (2004), an estimated reduction of sediment from the adoption of vegetative filter strip is approximately 53-97%, while the reductions of N and P are also estimated at 4-70% and 24-85%, respectively.

Grassed waterway

This practice is either natural or constructed channels for transporting of concentrated runoffs. Green and Haney (2005) explain that the vegetation improves water quality as it removes nutrients through plant uptake and soil absorption. Florida Department of Agriculture and Consumer Services (2004) suggests that the treatment areas are more effective in removing phosphorous attached to soil particles rather than dissolved N. Other advantages from this BMP are to decrease flow velocity thereby minimising soil erosion, and to provide habitats for widelife. The effectivenss of this BMP depends on soil characteristics, land slope, vegetation, construction area, and the width of the grassed waterway (Green and Haney 2005).

On-site retention storage

This BMP provides additional water storage; thereby assisting a long-term plan regarding water management and minimising off-site discharge during heavy rainfall (Florida Department of Agriculture and Consumer Services 2005). Moreover, this BMP also benefits in sediment reduction in that it allows settlement of particles and biological treatment of dissolved pollutants (SEPA 2010). In terms of water management, a sufficient size of pond to retain water for up to 120 days requires an area of 10% of cultivated land (DOAE 2002). The effectiveness of this BMP to reduce N and P particles are remarkably high, while its effectiveness to reduce dissolved N and P is considered medium to low (SEPA 2010).

Terracing

This BMP recommends a construction of wide steps on a gentle gradient for cultivated land with more than 30 degree slope. Wheaton and Monke (2001) argue that the major benefit from terracing is to reduce soil erosion. This is because terraces breake up one long slope and intercept rainfall runoff as it starts down a slope. Therefore, runoff is temporarily stored and the amount and velocity of the spilling water is minimised. Moreover, terraces keep eroded soil particles behind the terrace ridge; thereby reducing the potential of soil loss. Carman (2005) states that the potential reduction of soil erosion by this BMP ranges from 10-50%. This BMP is most effective when used in combination with other BMPs, such as conservation tillage and field borders.

Mix-load and wash-down site

Chemical spills results in expensively hazardous waste-cleanup and environmental contamination. This BMP aims to reduce the impacts from the spills. The construction of permanent mix-load and wash-down site provides a place where spills can be collected and cleaned (Florida Department of Agriculture and Consumer Services 2005). Furthermore, most farmers can receive the delivery of pestcides at sites where mixing and loading occurs. Stover et al. (2002) suggest that pesticide storage should be built within a permanent mix-load and wash-down site to avoid exposure to rain and wind. The suitable site for this BMP should have no direct linkages to yard drains or ditches. The site should be 10 m away from watercourses or 50 m from groundwater sources. The effectiveness of this BMP is site dependent (SEPA 2010).

Riparian setbacks

This practice requires an established distances between natural watercourse and cultivated land where soil disturbing activities are prohibited. In the context of citrus plantation, setbacks could contribute to manage the offsite nutrient impacts. The setbacks also protect and preserve native riparian and wildlife habitat (Florida Department of Agriculture and Consumer Services 2005). The effectiveness of this BMP at removing sediments is site dependent and related to many factors. The study of Chagrin River Watershed Partners (2006) showed that the effectiveness of riparian buffer is directly related to its width and land slope. For example, a 46 m riparian setback is needed on a 3% slope to reduce sediment transport by 90%. Mayer et al. (2006)'s study revealed that the effectiveness of this BMP depends on types of vegetative cover and buffer width. For example, N removal is predicted at 50% with the 16 m width grass cover, and increases to 75% with the 47 m width grass cover. With a combination of grass and forest cover, N removal is predicted to be 50% with only the 5 m width, and increases to 75% with the 20 m width of buffer strip.

3.3 Cost Statement of BMPs for Citrus Production in the Ping River Basin

In terms of BMP adoption there are at least two components of cost facing farmers. These are the installation and annual maintenance of BMPs, and the opportunity cost due to the lost production of the land used for BMP installation (Field et al. 2006; Wossink and Osmond 2002). The installation costs will occur in the first year when the BMP is installed, whist other costs such as maintenance, and opportunity costs may occur yearly through the life of BMP implementation.

The bottom-up engineering approach is used to estimate BMP cost. In doing so, all elements of work are listed, and the costs associated with each work item are assigned and summed to obtain the total cost (Afari-Sefa et al. 2008). Cost components are derived from US EPA (2008; 2000). Based on the worksheet calculated by engineer and agronomist (Khamkanya 2009; Namruengsri 2008), cost figures are estimated item-by-item (see Annex 2). Costs of materials employed in BMP construction and establishment is estimated using 2007 prices obtained from local retailers, and machinery and equipment is assumed to be rented at 2007 retail rates. The cost components of each BMP are illustrated in Table 3-2. The unit measurement is illustrated in terms of THB/ rai[9].

Table 3-2: Cost components of BMPs (Year 2007)

unit: THB[1]/ rai

	BMPs	Installation costs[2]	Annual maintenance costs[3]	Land opportunity costs[4,5]
Good Husbandry				
1	Scheduling water structure	2,250	300	-
2	Apply herbicide within tree canopy	-	882	-
3	Basic restrictions for pesticide application	1,360	30	-
4	Soil analysis	3,300	1,650	-
Vegetative Practices				
5	Vegetative cover	1,200	400	-
6	Mulching	882	294	-
7	Vegetative buffer strip	1,125	90	Approx. 3,842– 6,402[6]
8	Grassed waterway	1,365	120	Approx. 6,402 – 8,963[7]
Structural Practices				
9	On-site retention storage	15,155	765	Approx. 10,244–12,805[8]
10	Terracing	1,847	935	-
11	Mix-load and wash-down site[9]	5,181	259	Approx. 3,841
12	Riparian setbacks	163	20	Approx. 2,561 – 3,842[10]

Notes:

(1) An average exchange rate Year 2007; GBP1 = THB69.53 (Bank of Thailand 2010b)
(2) Instalment costs occur in the first year when BMP is installed
(3) Annual maintenance cost such as machinery and labour cost is to ensure the effectiveness of BMPs
(4) Annual opportunity cost of land recognises the forgone opportunity of continuity the production of crops on the land used for BMPs. It is calculated as gross margins of the crops, which is a value of output minus variable costs.
(5) The calculation is based on the assumption that each tree yields THB1280.4 per annum as shown in Table 3-1. This calculation also acknowledged that one rai accommodates 65 trees.
(6) This BMP requires at least 6m x 15m for critical zone in the field, thus it could cause a loss of 3-5 trees
(7) This BMP requires an area of 2.5m x 40m, thus it could cause a loss of 5-7 trees
(8) This BMP requires an area of 160m^2/ rai, thus it could cause a loss of 8-10 tress
(9) Cost estimate of this practice varies by farm size. The calculation is presented in Annex 3
(10) This BMP requires an area of 40m^2/ rai, thus it could cause a loss of 2-3 trees

3.3.1 Installation and Annual Maintenance Costs

Scheduling water structure

The construction of water structures (i.e. irrigation ditches) requires earthwork such as excavation and planning of irrigation routes. There is further work removing unwanted tress from the ditch lines. This costs approximately THB2,250/ rai. In the following years to

[9] A land measurement unit in Thailand; 1 rai = 0.16 ha

maintain the ditch cross-sectional area, costs include ditch maintenance such as weed control and sediment removal. This could cost THB300/ rai/ year.

Herbicide application within tree canopy

No installation cost is required for this practice. The cost of applying herbicide within the tree canopy depends on several factors such as weed species, number and size of weeds, weather condition, soil moisture and selective herbicide. To maintain the effectiveness of this practice, the use of herbicide should be structured to maintain desired vegetation. For example, applications should remove broadleaf vegetation while maintain grasses. The estimated maintenance costs should not exceed THB882/ rai/ year including labour and equipment.

Basic restrictions on pesticide application

The first year costs include spraying equipment and its accessories. This could cost approximately THB1,360/ rai. Yearly maintenance includes labour and equipment replacement, which are as low as THB30/ rai.

Soil analysis

The first year costs include soil collection equipment and soil collection training, analysis services, interpretation manual, and use of appropriate organic fertiliser to target area. This could cost THB3,300/ rai. Effective nutrient management in the following year requires analysis services and use of appropriate organic fertiliser. This should not exceed THB1,650/ rai/ year.

Vegetative cover

The establishment costs of this BMP are based on seedling and types of grass matching with the climatic conditions in the Ping river basin. Types of grass and seeding method affect the cost of seeds and tillage. However, it is estimated that overall installation costs should not exceed THB1,200/ rai. Yearly maintenance costs are THB400/ rai including reseeding in destroyed areas and vegetative maintenance.

Mulching

The installation costs include materials such as straw or plastic sheeting. Labour costs are incurred during the processes of mulching. Overall costs should not exceed THB882/ rai. Proper maintenance includes re-mulching and re-layering and these can cost THB294/ rai/ year.

Vegetative buffer strip

If land is cleared and graded, installation of buffer strip could cost THB1,125/ rai. To maintain the effectiveness of this practice, any excessive sediment on the buffer strip should be removed periodically and the strip should be reseeded as necessary. Furthermore, the strip should be mowed regularly. This yearly maintenance could cost THB90/ rai.

Grassed waterway

The establishing costs of this BMP vary depending on the equipment and labour costs, grading, seed and fertiliser selected. Overall costs, however, should not exceed THB1,356/ rai. Once the vegetation is established its maintenance costs are minimal. These costs include repairing rills and gullies and removing accumulation of deposited sediment, which can be low as THB120/ rai.

On-site retention pond

Site selection is important in terms of topography, water supply and soil type. Installation costs are varied and largely cover earthworks. The pond size of 10% of total planted area can store water for up to 120 days. Therefore, the construction costs are expected to be approximately THB15,155/ rai (for a pond sized 12.65m x 12.65m x 3m). Maintenance costs are low but care may be needed for removal of excessive sediments. Trimming and replanting vetiver grass is sometimes needed, if plant around the edges of a pond to prevent sediment eroded from the pond’s edges. These annual maintenance costs should not exceed THB765/ pond.

Terracing

Construction costs of terracing include earthwork to build terraces and outlet facilities. Additional costs cover the vegetation establishment. Construction costs vary greatly depending on the size of terrace and outlet. Typically, construction costs should not exceed THB1,847/ rai. Periodic and post-run-off inspections are required with prompt repair of damaged components. Moreover, maintenance of ridge height and outlet elevations, removal of excessive sediment, and maintenance of the vegetated area that may require replanting are also needed. These yearly maintenance costs are approximately THB935/ rai.

Mix-load and wash-down site

This practice requires an installation of chemical storage, and mix-load and wash-down areas. Literature suggests that the size of functional areas of an operation depends on the amount of pesticides stored at the facility (US Army Center for Public Works 1997; Kammel and O'Neil 1990), and storage area should able to hold at least 10% more than chemicals applied in latest season (Sumner and Bader 2009; Dean 2004). Accordingly, cost estimates for this practice are based on the concept of mixed costs. That is, costs contain both fixed and variable costs, and are partly affected by change in the level of activity (i.e. farm size and chemicals application). Assumptions for cost estimates are presented in Annex 3. Average installation cost is as high as THB 5,181/rai, while the annual maintenance cost is estimated at THB259/rai.

Riparian setback

The setback distances are established from the edge of stream where riparian areas are left as natural as possible. Typically, setback widths of 9.15m can serve an area of approximately 80.95rai (Geauga Soil and Water Conservation District 2006). With the assumption that a farm has a square shape, an area of around 40.65m^2/ rai is thus required for setback areas. Though existing natural vegetation is usually preferred, planted stock may be used. The overall installation costs are estimated at THB163/ rai. Annual maintenance costs include subsequent cutting/ trimming, selective herbicide application, and replanting or reseeding some damaged areas. These costs should not exceed THB20/ rai.

Figure 3-3 illustrates the proportion of installation and annual maintenance costs. The results show that the construction costs occurred in the first year is very important for every BMP adoption, excluding practice 2 (applying herbicide within tree canopy) from Good Husbandry category.

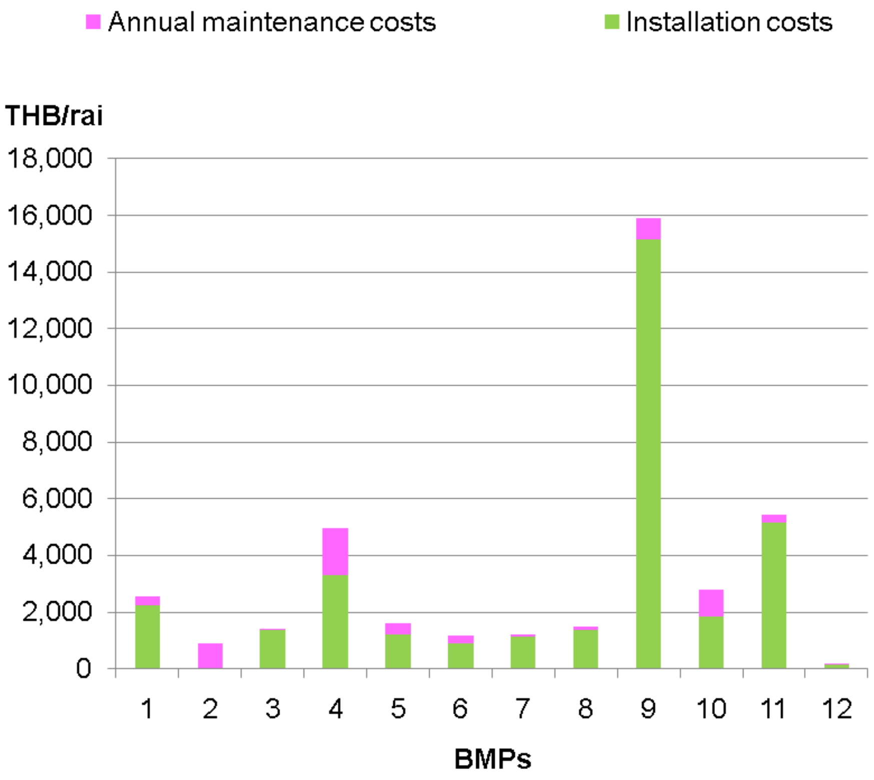

Figure 3-3: Proportion of installation cost and annual maintenance cost (%)

Notes: The horizontal axis represents twelve BMPs. From left to right, Good Husbandry category includes practice number 1-4: 1) scheduling water structure; 2) apply herbicide within tree canopy; 3) basic restrictions for pesticide application; and 4) soil analysis. Vegetative Practice category includes practice number 5-8: 5) vegetative cover; 6) mulching; 7) vegetative buffer strip; and 8) grassed waterway. Structural Practice category includes practice number 9-12: 9) on-site retention storage; 10) terracing; 11) mix-load and wash-down site; and 12) riparian setbacks.

3.3.2 Land Opportunity Costs

Land opportunity cost occurs from taking land out of production. In this study, it is based on related square meter of land necessary to build the appropriately sized BMP as recommended by US EPA (2008). Annual opportunity cost of land is calculated as gross margins of the crops (Wossink and Osmond 2002). The calculation is based on the assumption that each rai can accommodate 65 trees, and each tree yields THB1280.4/ year (i.e. this is a return over variable costs).

In this study, five BMPs incur land opportunity costs. These are vegetative buffer strips, grassed waterways, an on-site retention pond, a mix-load and wash-down site, and riparian setbacks. The opportunity costs of the remaining practices are considered zero (Table 3-2). The installation of vegetative buffer strip is recommended only in critical zone in the field, and the land opportunity cost is approximately estimated as THB3,842 – THB6,402/ rai. Land opportunity cost for grassed waterway can be estimated to range from THB6,402 – THB8,963/ rai. The construction of on-site retention pond causes a land opportunity cost of as high as THB10,244 – THB 12,805/ rai. The opportunity cost for installation of permanent station for mix-load and wash-down is estimated at THB3,841/rai. Finally, the opportunity cost for the establishment of riparian setback is estimated as around THB2,561 – THB3,842/ rai.

3.4 Annualised Costs

The expected lifetime of each BMP varies. For cost comparison, installation costs are reduced to annual values using the relationship (Gitau et al. 2004) in equation 1:

$$A_{BMP} = \frac{Z\left(\frac{r}{100}\right)}{1-\left(1+\frac{r}{100}\right)^{-n}} \qquad \text{(Equation 1)}$$

where

A_{BMP}	Annualised cost for BMP (THB)
Z	Capital cost of a BMP (THB)
r	Time value of money or the private discount rate (%)
n	Expected lifetime of the BMP (years)

It is assumed that Good Husbandry will have a one year lifespan, while Vegetative and Structural Practices are expected to have a longer lifespan. Based on agronomy and engineering aspects, the expected lifespan of Vegetative and Structural BMPs are presented in Table 3-3. To capture all economic costs, opportunity costs were included in the cost analysis.

Table 3-3: Expected lifespan for Vegetative and Structural Practices

BMPs	Lifespan (years)
Vegetative Practices	
Vegetative cover	5
Mulching	3
Vegetative buffer strip	10
Grassed waterway	10
Structural Practices	
On-site retention pond	10
Terracing	10
mix-load and wash-down site	10
Riparian setbacks	10

Gregersen and Contreras (1992) argued that, from a private investor's point of view, estimated average bank lending rate should be used as a discount rate. They further suggested that private discount rate varies from situation to situation. As such, in this study, three discount rates are offered for a comparative purpose. The first discount rate refers to the Bangkok Interbank Offered Rate (BIBOR), which is the rate of interest at which commercial banks borrow fund from other banks in the Bangkok interbank market. In year 2007, the average BIBOR was approximately 4% (Bank of Thailand 2010a). The second discount rate is that normally applied in academic work for any project carried out in Thailand. This rate is set as 10% (Sajjakulnukit and Verapong 2003; Niskanen 1998). The third discount rate represents the rate at which farmers borrow money from the bank and pay a real annual interest rate. The rate from the Bank of Agriculture and Agricultural Cooperatives (BAAC) is used as a proxy and it is as high as 13% (BAAC 2010). Table 3-4 presents the total annualised costs of each BMP.

Table 3-4: Annualised cost estimates for twelve BMPs

unit: THB/ rai

BMPs	Installation costs	Annual maintenance costs	Average land opportunity costs[1]	Annualised installation cost			Total annualised costs		
				4%	10%	13%	4%	10%	13%
Good Husbandry									
1. Scheduling water structure	2,250	300	-	2,340	2,475	2,543	2,640	2,775	2,843
2. Herbicide application within tree canopy	-	882	-	-	-	-	882	882	882
3. Basic restrictions for pesticide application	1,360	30	-	1,414	1,496	1,537	1,444	1,526	1,567
4. Soil analysis	3,300	1,650	-	3,432	3,630	3,729	5,082	5,280	5,379
Vegetative Practice									
5. Vegetative cover	1,200	400	-	270	317	341	670	717	741
6. Mulching	882	294	-	318	355	374	612	649	668
7. Vegetative buffer strip	1,125	90	5,122	139	183	207	5,351	5,395	5,419
8. Grassed waterway	1,365	120	7,683	169	222	252	7,971	8,025	8,054
Structural Practice									
9. On-site retention storage	15,155	765	11,525	1,869	2,466	2,793	14,158	14,756	15,082
10. Terracing	1,847	935	-	228	301	340	1,163	1,236	1,275
11. Mix-load and wash-down site	5,181	259	3,841	639	843	955	4,739	4,943	5,055
12. Riparian setbacks	163	20	3,202	20	27	30	3,242	3,248	3,252

Notes: 1) Average value is used as a proxy of land opportunity costs

By comparison, at any discount rate, practice 9 (on-site retention pond) has the highest total annualised cost. At 13% discount rate, for example, the total annualised cost of practice 9 is as high as THB 15,082/ rai (Table 3-4; Figure 3-4). This high annualised cost is due to the land opportunity cost as a proportion of total cost. Further, amongst all BMPs the top three practices having the highest total annualised cost are also those having the highest opportunity cost (practice 7, 8, and 9) (Figure 3-4). The finding indicates that opportunity cost (i.e. land requirement) is the critical determinant of conservation practice.

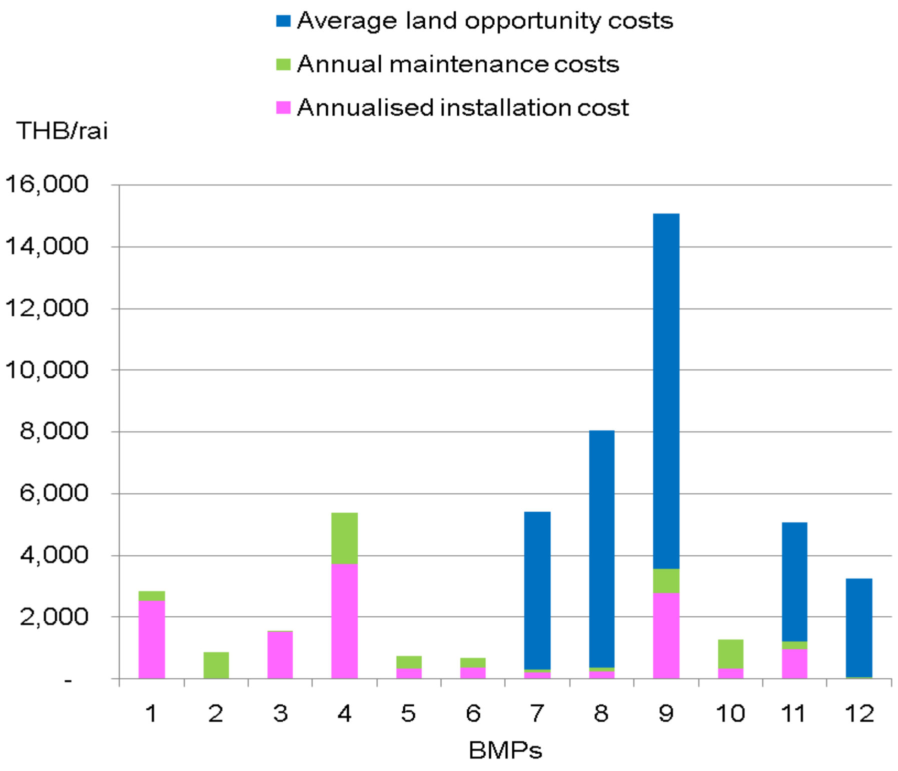

Figure 3-4: Economic cost of BMPs (at 13% discount rate)

Notes: The horizontal axis represents twelve BMPs. From left to right, Good Husbandry category includes practice number 1-4: 1) scheduling water structure; 2) apply herbicide within tree canopy; 3) basic restrictions for pesticide application; and 4) soil analysis. Vegetative Practice category includes practice number 5-8: 5) vegetative cover; 6) mulching; 7) vegetative buffer strip; and 8) grassed waterway. Structural Practice category includes practice number 9-12: 9) on-site retention storage; 10) terracing; 11) mix-load and wash-down site; and 12) riparian setbacks.

3.5 Discussion

Cost analysis in this chapter offers a better understanding of the key financial factors that might influence farmers' adoption intention. The value transfer of these estimated costs to other studies must be done with care because the cost estimates related to the implementation of BMPs in citrus farms are site-specific. For example, the installation cost of practice 10 (terracing) was calculated for the terrace system that is suitable for citrus farms. The opportunity cost was calculated based on yield reduction. The use of these cost figures for other crops or other areas in the country may not appropriate. However, the lists of cost elements represent diverse conditions over the entire country, and policymakers can adopt these cost elements as guidelines for a cost estimate of BMPs in other studies.

Overall, this study provides basic information about the total amount of money required for establishing a particular BMP at farm level. It also offers a comparison of annualised costs between various BMPs. This information is critical to guide policymakers about how to allocate public resources in order to encourage BMP adoption (Afari-Sefa et al. 2008; Wossink and Osmond 2002). Though cost estimates cannot provide conclusive evidence for predicting any desired water quality level, cost information can provide some insights about whether farmers make decisions based on costs. This can be further investigated in comparison with frequency of adoption intention (i.e. stated intention which will be derived from the application of TPB in chapter 4). In sum, economic cost estimates can offer insights into economic clarity around implementation costs of BMPs, allow a comparison of various BMPs, and provide understanding about whether farmers make decisions based on costs.

3.6 Summary

The analysis in this chapter stems from the notion that cost is one barrier in the adoption of new technologies. The objectives of this chapter are to i) illustrate the farm budget in citrus production; ii) present BMP functions and its potential benefits and effectiveness; and iii) estimate the cost of BMP adoption and understand cost structure of BMPs recommended for citrus farms in the Ping river basin. BMP costs are separated into installation cost, annual maintenance cost, and land opportunity cost. BMP costs were based on the bottom-up approach. By doing so, labour-hours and materials of each element of work are estimated, priced and accumulated into a total cost. For comparison, annualised cost was calculated for capital cost of BMPs which have different lifespans. The analysis revealed that installation cost is very important in BMP adoption, but for some BMPs, particularly those in Vegetative Practice and Structural Practice categories, land opportunity cost outweighs the installation and annual maintenance costs. The cost information is useful in the design of PES programme. Provided that costs influence farmers' adoption, these costs could indicate the level of incentive payments to induce farmers' participation. The main conclusion derived from this analysis is that in terms of actual cost, land opportunity cost is a large proportion of total costs. This is followed by first-year installation cost and annual maintenance cost.

4 A MODIFICATION OF THE THEORY OF PLANNED BEHAVIOUR

The literature review in chapter 2 shows that there are differences in underlying assumptions between economics and psychology. To a degree, adoption models provide little attention to psychological variables influencing behaviours and adoption intentions (Shogren and Taylor 2008). Hence, an alternative approach is needed to understand human behaviour better. This chapter introduces a psychological theory, the Theory of Planned Behaviour (TPB), to supplement the economic model of BMP adoption. The scope of analysis is based on the integration of the TPB and statistical analysis (Figure 4-1).

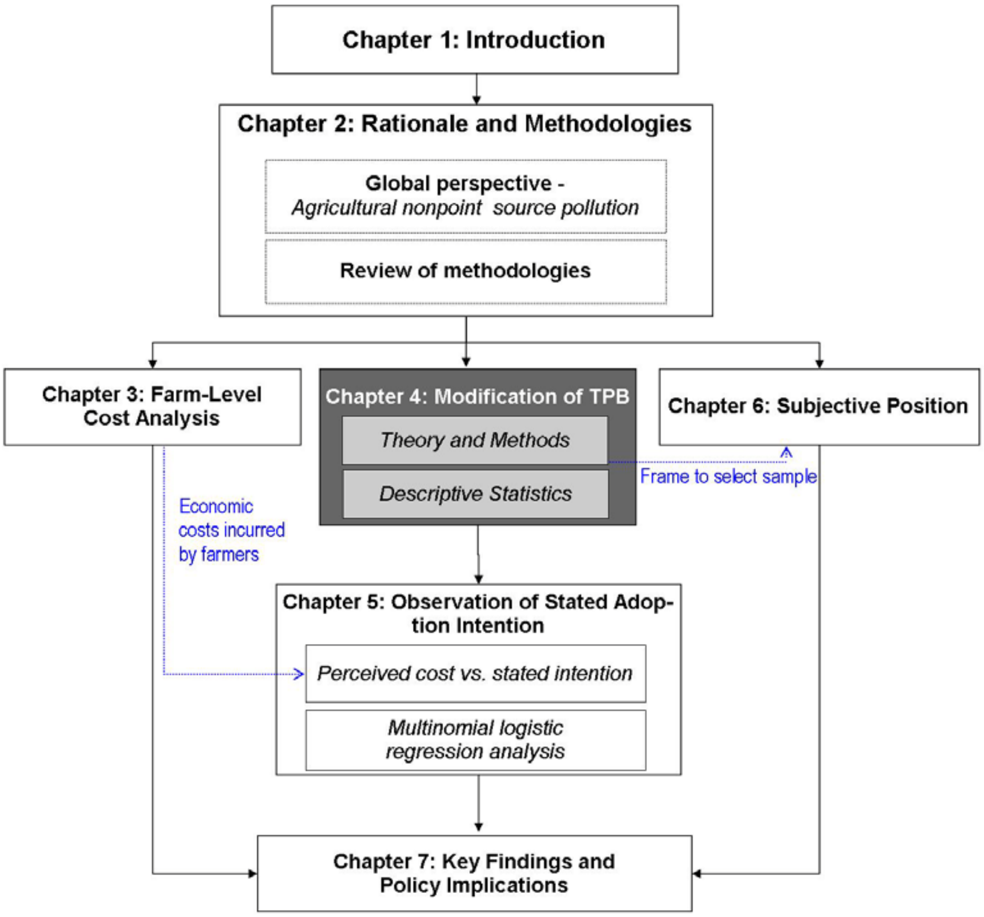

Figure 4-1: Thesis structure

Section 4.1 reviews the application of TPB in the domain of environmental policy, followed by a transitivity concept in relation to farmers' preferences towards BMPs. Then, it presents how to obtain psychological variables through an elicitation study and content analysis, and further discusses external variables to be considered in this adoption intention study. These variables will be included in a questionnaire, and treated as independent variables. Next, the processes of questionnaire development and fieldwork administration are then outlined. Section 4.2 presents descriptive statistics of farmers. This chapter closes with a summary of the main findings (section 4.3).

4.1 Theory of Planned Behaviour

4.1.1 Basic TPB constructs and the concept of behavioural intention

TPB attempts to explain human behaviour. It postulates that a particular behaviour can be predicted from the behavioural intention to perform such behaviour. This intention can be predicted from three psychological constructs: attitude towards the behaviour; subjective norm about the behaviour; and perceived behavioural control of the behaviour (Ajzen 2006; Ajzen 1991) (Figure 4-2). The common method to measure these three variables is a survey using a TPB-constructed questionnaire. In this section are the three basic constructs of the TPB and evaluation of behaviour.

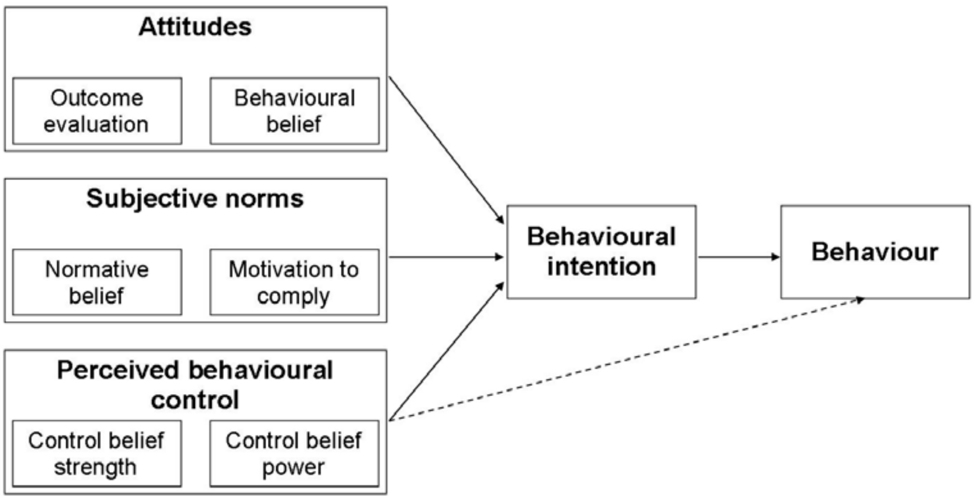

Figure 4-2: Basic TPB model

Sources: adapted from Ajzen (2006), and Ajzen (1991)

4.1.1.1 Attitude

Attitude is the overall positive and negative evaluation of performing the behaviour. It is a product of personal evaluation of the outcome associated with the behaviour (or outcome evaluation) indexed by personal perception about the consequence of the behaviour (or behavioural belief). It is hypothesised that the more favourable the attitude, the more likely the adoption.

4.1.1.2 Subjective norm

Subjective norm is the perceived social pressure whether to perform. It is the product of belief about how referent group would like an individual to behave (or normative belief) indexed by likelihood of compliance (or motivation to comply). It is hypothesised that the more favourable the subjective norm, the stronger an individual's intention to have that behaviour.

4.1.1.3 Perceived behavioural control

This is the degree in which an individual feels able to perform. It is assumed to reflect past experiences and anticipated impediments. Perceived behavioural control is a product of belief about both situational and internal factors controlling the behaviour (or control belief strength) indexed by perceived power of these factors (or control belief power). It is hypothesised that the greater the perceived behavioural control, the more likely the adoption.

4.1.1.4 Behavioural intention

According to the TPB, intention is assumed to be an approximate measure of actual behaviour. Behaviour is determined based on an individual's intention to perform or not perform an action (Ajzen 1991). Most TPB studies apply a multipoint scale (i.e. 7-point scale) to measure a common dimension of intention (e.g. from scale of 1 to 7, how likely do you think you will perform *n* activity?). Intention is conceptualised as a probability continuum, and further transformed into a dichotomous behaviour representing a YES/NO response. Intention and actual behaviour are assumed to have a linear relationship (i.e. the greater the intention, the greater the probability of actual behaviour performing) (Sutton 1998). This could cause a lack of correspondence because there are seven points on the intention scale but only two for behaviour (Luzzi and Spencer 2008). Further, this could raise the argument of how well intention can predict the actual behaviour with considerable accuracy. According to Sutton (1998), intention can be treated as a dichotomous outcome variable which could allow the possibility of a better prediction for behaviour. A few TPB studies attempt to assess the link between intention and actual behaviour by defining intention in terms of a dichotomous dependent variable (Wauters et al. 2010; Mayet and Niess 2008; Fagan et al. 2008; Gabler and Jones 2000).

On a related point, actual behaviour is the result of competition amongst options (Laroche and Sadokierski 1994), and behavioural intention can be better predicted when people are asked to consider relative distinctiveness amongst options (Axelrod 1968). As such, a construction of more specific questions, such as those giving choices and asking for selection, and situation-based questions are superior and can increase the probability of getting accurate responses (Ovans 1998). Similarly, a set of intention simulations imitating real situations could be a more valid proxy measure for actual behaviour, because it more closely approximates the condition that requires complex decisions (Francis et al. 2004).

Taking into account the debate over the nature of behavioural intention and previous works relating to BMP adoption, 12 specific BMPs (see Table 1-5, Chapter 1) became the basis of both the belief and behavioural sections of the questionnaire to study farmers' adoption decision as a dichotomous choice. Each measure was encouraged by agronomists for reasons of practicality and suitability to the study area. The next section describes a ranking process relating to adoption intention.

4.1.2 Rank-ordering of the options

According to Greiner et al. (2009), farmers will adopt an innovation if they expect that the practice helps them achieve social, economic, environmental and other goals. In other words, farmers decide which BMP according to its anticipated consequences. Throughout, this study assumes that each BMP possesses an inherent desirability and farmers determine how likely a particular BMP is to be preferred to another. This implication is based on the concept of transitivity of an individual's preferences (Wu and Annis 2007), and this type of response is classified as sentiment where there is no veridical comparison[10] (Nunnally 1978). The transitivity concept could be defined as: if A is preferred to B; and B is preferred to C; then A is preferred to C.

In this study, twelve intention simulations representing corresponding BMPs were presented to participants. The BMPs were presented as a proxy service in a PES programme. The main messages sent to farmers were that the adoption will lead to an improvement in water quality and those who adopt BMPs will be compensated by the beneficiaries downstream. Each simulation comprised basic information, including implementation methods, relevant environmental benefits from adoption, and cost components of each BMP. Both benefit and cost figures were not presented to farmers. This is because in terms of benefits there is a limited reliable estimation related to science-based water quality improvement (Stanley 2000), while costs of BMP adoption tend to vary substantially by farm and even across farm fields within a single farm depending on many factors such as geography, climate, and farming practices. Further, for some BMPs the costs are difficult to quantify because of their indirect and highly variable implementation level (US EPA 2004). Another issue why an objective cost is not presented to participants is that this thesis considers BMPs in the context of PES. Under the PES programme, costs incurred by farmers will be covered by transfer payments from beneficiaries. Hence, objective costs are not pertinent to the subject under consideration.

Further question may arise as to what extent farmers consider the effectiveness of BMPs in their decision makings. At the individual farm scale farmers know best the most vulnerable location of their farms, and thus they tend to choose BMPs that could potentially solve a relevant environmental problem (Ellen et al. 1991; Cary and Wilkinson 1997). However, the actual BMP effectiveness and the effectiveness perceived by farmers are different. Farmers' perceptions about BMP effectiveness are formed by familiarity with the practices (Matthew et al. 1993), environmental awareness, adaptability with new practices and acquired knowledge (Sattler and Nagel 2010). On the contrary, the actual effectiveness of BMPs is monitored in an experiment site (Otto et al. 2008; Borin et al. 2005). Factors affecting the

[10] Two types of response are judgment and sentiment. Judgment is used to cover all responses where there is some veridical comparison for the subject's response, and it is possible to determine whether each response is correct (i.e. which of two is heavier?). On the other hand, sentiment is used to cover all responses concerning personal reaction, preferences, interests, attitudes, values, likes and dislikes, and there is no physical scale for sentiment.

actual effectiveness of BMPs are, for example, climatic conditions, sources of pollution, and runoff volume.

Overall, farmers' perceived effectiveness covers a range of aspects related to production goals. Their understanding focuses on 'know how' or practical knowledge at the farm level in the interactions between the factors influencing crop production other than 'know why' in the ecological function (Ingram et al. 2010). Pannell et al. (2006) argued that, for an individual farmer, adoption is based on subjective perceptions rather than on scientific information because environmental advantage is not always clearly observable. This argument is reinforced in particular when positive perception in benefits and effectiveness of BMPs is important for an ex-ante decision in the evaluation of voluntary adoption (Husak et al. 2004). Accordingly, throughout the thesis farmers were asked to self-evaluate between 'perceived benefits' (refer to environmental benefits of BMP, section 3.2) from, and 'perceived costs' (refer to cost structure of BMP, section 3.3) of, BMP adoption. This process is in line with the discussion made by Lutz et al. (1994) that farmers' decisions to invest in new technology are often based on estimated net benefits and personal interest.

At this point adoption intention was designed as a dichotomous choice, adopt or not, leading to discretionary behaviour. Empirical studies have shown that more choices and more information could be overwhelming and led to a feeling of helplessness or reduced self-efficiency (Dawnay and Shah 2005). Thus, after being presented with twelve scenarios participants were asked to select only three BMPs that they wanted to adopt at their farm. The selection criteria were based on personal preferences, personal need, the possibility of that practice being implemented on their farms (i.e. practicality, adaptability, and labour requirement), necessity, and achievement or goal of farm management. These criteria were set to reflect constraints relating to the adoption process. That is, farmers were asked to take account of possible outcomes, to compare the new alternative with the old technology, and to evaluate whether to adopt a new alternative (Guerin 1999).

The participants were then asked to interpret their three selected BMPs according to their individual preference ranking (i.e. 1st, 2nd, and 3rd orders). Though the preference ranking amongst several discrete BMPs may not be the absolute test for behavioural intention, it could be an initial predictor of some level of commitment. On a related point, arguments could arise when a multi-attribute measure granting a comparative judgment is applied. Participants were confronted with *n* possible solutions, but they were asked to choose only some BMPs. This could be a case if participants were forced to respond. However, in this study participants had the right to refuse selection if they were not sure. Farmers were allowed to select 'no adoption' if they desired as long as it was reasonable and followed the selection criteria. This is in line with the foundation of TPB in that choices are voluntary and individual is conscious of the consequences of adoption (East 1993).

In order that all participants in the TPB study consider the studied behaviour, i.e. BMP adoption, under the same situational condition, the behavioural intention must be defined in terms of its Target, Action, Context, and Time (TACT) (Ajzen 2006; Francis et al. 2004). The TACT was stated directly at the beginning of the interview and it was defined as:

> *If the government asks for voluntary adoption, consider the case of adopting activities that could reduce amount of pollutants discharged into watercourses in the next three years. (Carefully think about what you have just chosen as your preferred choices)*

4.1.3 Construction of psychological variables

4.1.3.1 Elicitation study

To establish a cognitive foundation for farmers' salient beliefs, an elicitation study is required. Face-to-face interviews were conducted in June 2007 with 17 citrus farmers in the Ping river basin. These farmers were randomly selected from the list of registered farmers with the Department of Agricultural Extension. Participants were presented with pictures illustrating impacts from citrus production on water quality, and then introduced to BMPs. They were interviewed with thirteen open-ended questions (Annex 4). Interviews were conducted in the local native language, and answers were written down verbatim.

4.1.3.2 Content analysis

Content analysis was conducted to determine ideas and themes from the responses (Fink 2003; Gillham 2000). Words and phrases were first defined and categorised into themes and sub-themes. Then, to be more specific, words and phases in each sub-theme were counted for frequency of occurrence. Those with high frequency and containing meaningful information were retained and assigned as items in the questionnaire. The content analysis yielded 13 psychological variables, which were four attitude variables, four subjective norm variables, and five perceived behavioural control variables (Table 4-1). A hypothesis relationship between these psychological variables and behavioural intention is also presented.

Table 4-1: Psychological variables

Variables	Study Hypotheses
Attitude variables	
Reduced production cost	+
Environmental protection	+
Benefits gained from watershed services	+
Greater commitment to farm management	-[1]
Subjective norm variables	
Consumers	+
Government	+
Agricultural input retailer	+
Neighbours	+
Perceived behavioural control variables	
Affordable	+
Return	+
Knowledge	+
Farmer's association	+
Potential market	+

Note: 1) The study hypothesises negative association with adoption intention. However, for ease of score computation and interpretation, scores of the negative item were reversed.

4.1.3.3 Psychological statements

Thirteen variables were used to create a set of indirect measures to reflect both personal beliefs and personal evaluations of farmers. Further, a set of direct measures was added to the questionnaire. An indirect measure is a belief-based measure asking participants about specific beliefs and outcome evaluation, while a direct measure is an evaluative measure asking participants about their overall attitudes towards behaviour (Francis et al. 2004). A seven point bipolar adjective scale was used to elicit farmer's adoption intentions regarding attitude, subjective norm and perceived behavioural control. For indirect measures, personal belief was scaled from 1 to 7, while personal evaluation was scaled from -3 to +3. For the direct measure, it was scaled from 1 to 7. Table 4-2 presents types of measure and numbers of corresponding questions as illustrated in section 2, Annex 5.

Table 4-2: Types of statement and corresponding question numbers

Types of statement	Question number[1]
Statements presenting direct measure	
Attitude	1
Subjective norm	3-5, 25
Perceived behavioural control	2, 6-8
Statements presenting indirect measure	
Attitude	
Personal belief: *behavioural belief*	9-12
Personal evaluation: *outcome evaluation*	18-21
Subjective norm	
Personal belief: *motivation to comply*	22-26
Personal evaluation: *normative belief*	27-30
Perceived behavioural control	
Personal belief: *control belief strength*	13-17
Personal evaluation: *control belief power*	31-35

Note: 1) as appeared in section 2, Annex 5

4.1.4 Additional variables

The TPB originally postulates three elements (attitude, subjective norm and perceived behavioural control) explaining behavioural intention. However, the model allows for the inclusion of other variables (Ajzen 1991: 199). Inclusion of additional variables in the model could increase the predictive power of actual behaviour (Fielding et al. 2008), and provide a theoretical coherence to results (Conner and Armitage 1998). Some research has shown that intention is better predicted when other factors are included alongside the traditional three variables (de Bruijn et al. 2005; Karppinen 2005; Cook et al. 2002). In the context of farmers' decision-making towards adoption of new agricultural technologies and policies, Edwards-Jones (2006) suggested that farmers' decisions are influenced by a range of factors which are integrally formed of psychological and other socio-economic variables. Accordingly, the TPB model is extended inclusion of four additional variable sets (Figure 4-3). These four variable sets are socio-demographics of farmer, characteristics of the farm household, structure of the farm business and social milieu. Their hypothesised relationship with adoption intention is presented in Table 4-3.

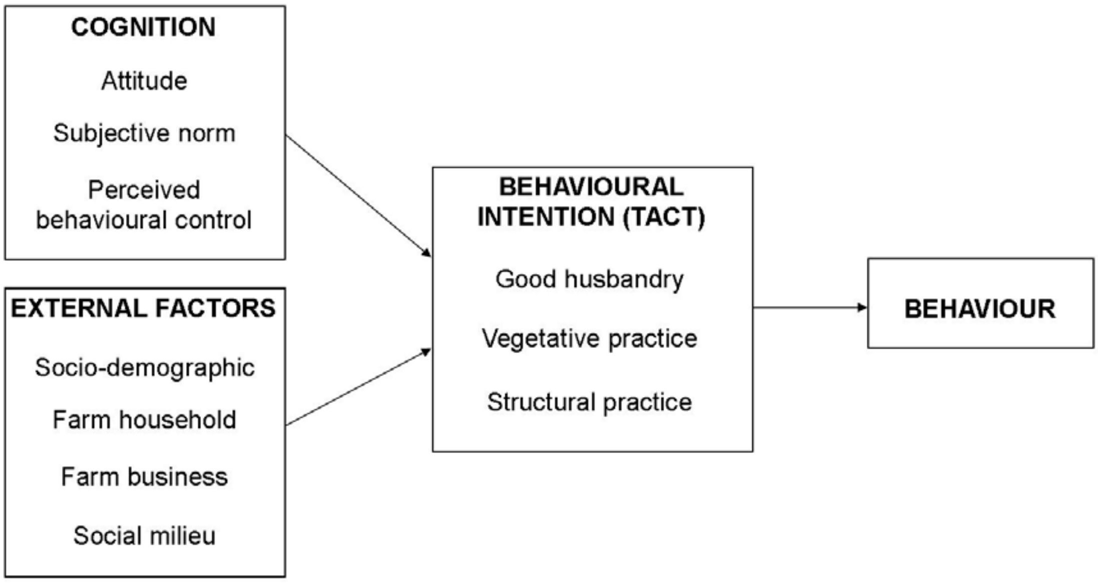

Figure 4-3: The TPB model

Source: adapted from Ajzen (1991), and Edwards-Jones (2006)

4.1.4.1 Cost determination

Basically, adoption intentions can be explained by both the classical microeconomic concept and the social psychology concept. The behaviour of economic agents described by economic theory is based on normative concepts, in that the individual is assumed to have bounded rationality and to maximise his utility. On the other hand, behaviour explained by social psychology follows a positive approach, and relies on behavioural determinants as antecedents to individual’s intention (Dierks 2005). The introduction of the social psychology concept into economic study has been done to explain the adoption process of intended behaviour (Spash et al. 2009). In order to assess willingness to adopt according to implementation costs of BMPs, a questionnaire must be designed based on a stated preference approach. However, studies reveal that a TPB structured questionnaire could only include perceived costs as variables in the analyses (Rehman et al. 2007; Fielding et al. 2005). This reflects a methodological incompatibility between social psychology and economics. As the introduction of cost into the TPB framework is uncertain, cost is excluded from this model.

Table 4-3: Additional variables

Variables	References	Modes of Technology Adoption	Findings	Study Hypotheses
Socio-demographic of the farmers				
Age	Rodriguez et al. (2009)	Sustainable agricultural practices	-	-
	Sriwichailamphan et al. (2008)	Good Agricultural Practices	-	
	Sheikh et al. (2003)	No-tillage practices	-	
	Zubair and Garforth (2006)	Agroforestry	-	
Education level	Rodriguez et al. (2009)	Sustainable agricultural practices	+	+
	Zubair and Garforth (2006)	Agroforestry	+	
	Sheikh et al. (2003)	No-tillage practices	+	
	Doss and Morris (2001)	Modern varieties and fertiliser	+	
	Fulgie (1999)	Conservation tillage and pesticide	+	
	Traore et al. (1998)	BMPs	+	
	Feather and Cooper (1995)	Nonpoint source pollution control	+	
	Kerns and Kramer (1985)	Nonpoint source pollution control	+	
	Ervin and Ervin (1982)	Soil conservation practices	+	
Gender	Gillespie et al. (2007)	BMPs	+ (male)	n/a
	Tenge et al. (2004)	Soil and water conservation	+ (female)	
	Adesina and Chianu (2002)	Alley farming technology	- (female)	
Characteristics of the farm household				
Dependence on other crops	Gillespie et al. (2007)	BMPs	+	+
	Fernandez-Cornejo et al. (1994)	Integrated Pest Management	+	
Past experiences in farming	Nyaupane and Gillespie (2009)	BMPs	+	n/a
	Ribaudo et al. (1999)	Nonpoint source pollution control	-	
	Traore et al. (1998)	BMPs	-	
Health condition	Traore et al. (1998)	BMPs	+	+
	Rahm and Huffman (1984)	Reduced tillage	+	

Variables	References	Modes of Technology Adoption	Findings	Study Hypotheses
Structures of the farm business				
Farm size	Nyaupane and Gillespie (2009)	BMPs	-	n/a
	Larson et al. (2007).	BMPs	+	
	Zubair and Garforth (2006)	Agroforestry	+	
	Beedell and Rehman (2000)	Conservation practices	+	
	Fernandez-Cornejo et al. (1994)	Integrated Pest Management	+	
	Earle et al. (1979)	Soil conservation	+	
	Feder et al. (1985)	Agricultural innovation	-	
	Greene (1973)	Agricultural innovation	-	
Location	Ribaudo et al. (1999)	Nonpoint source pollution control	Depend on type of technology	n/a
Any stream run through	Rahelizatovo (2002)	BMPs	+	+
	Gillespie et al. (2007)	BMPs	+	
Soil type (i.e. natural fertility, drainage efficiency, erosion susceptibility)	Zhou et al. (2008)	Water saving technology	-	-
	Rahm and Huffman (1984)	Reduced tillage	-	
Contribution of family labour in farm activity	Gillespie et al. (2007)	BMPs	+	+
	Fernandez-Cornejo et al. (1994)	Integrated Pest Management	+	
Land ownership	Nyaupane and Gillespie (2009)	BMPs	- (tenant)	+ (owner)
	Oates (2006)	Good Agricultural Practices	- (tenant)	
	Zubair and Garforth (2006)	Agroforestry	+ (owner)	
	Sheikh et al. (2003)	No-tillage practices	+ (owner)/ - (tenant)	
	Herath and Takeya (2003)	Intercropping		
	Soule and Tegene (2000)	Conservation practices	+ (owner)	
	Fernandez-Cornejo et al. (1994)	Integrated Pest Management	+(owner) - (tenant)	
Household income	Rodriguez et al. (2009)	Sustainable agricultural practices	+	+
	Gillespie et al. (2007)	BMPs	+	
	Sheikh et al. (2003)	No-tillage practices	+	
	Ribaudo et al. (1999)	Nonpoint source pollution control	+	
Household debt	Oates (2006)	Good Agricultural Practices	-	-
Social milieu				
Membership of farmers' agricultural association	Herath and Takeya (2003)	Intercropping	+	+
	Beedell and Rehman (2000)	Conservation practices	+	
Access into government advisory services	Herath and Takeya (2003)	Intercropping	+ (easy)	+ (easy)
	Henning and Cardona (2000)	BMPs	+ (easy)	
Access into other sources of advisory services	Gillespie et al. (2007)	BMPs	+ (easy)	+ (easy)
	Traore et al. (1998)	Conservation practices	+ (easy)	
	Feather and Cooper (1995)	Nonpoint source pollution control	+ (easy)	

4.1.4.2 Socio-demographics of the farmers

Age

According to Rodriguez et al. (2009), older farmers are less likely to consider new production practices because they may be ‘ready to retire’ and ‘do not have the years to see more benefits’. Previous research has also shown that younger farmers were more likely to adopt conservative practices on their farms (Sriwichailanphan et al. 2008; Zubair and Garforth 2006; Sheikh et al. 2003). Thus, a negative impact of age on an adoption of BMPs is expected.

Education level

It is hypothesised that more educated farmers are able to understand and obtain information about environmental problems, such as water quality degradation, which not only affects their own farms but also the watershed system. Kerns and Kramer (1985) explained that highly educated farmers may have better access to information, and better managerial skills. These could potentially increase the effort to adopt conservation practices. Lack of knowledge deters farmers from adopting new technology as this increases the uncertainty in changing to something unknown (Rodriguez et al. 2009). Plenty of empirical studies show that education level is positively related to the adoption rate of more eco-friendly practices (Zubair and Garforth 2006; Sheikh et al. 2003; Doss and Morris 2001; Fulgie 1999; Traore et al. 1998; Feather and Cooper 1995; Ervin and Ervin 1982). Hence, a positive impact of education level on a BMPs uptake is expected.

Gender

Gender relates to the issue of adoption because male and female farmers may hold different preferences when considering new practices. Other things being equal, they may face different constraints when it comes to new technology uptake (Doss and Morris 2001). The role of gender on the uptake of more eco-friendly practices is not very clear (Gillespie et al. 2007; Tenge et al. 2004). Gender bias could occur in land allocation, inheritance systems, or even in testing and demonstration process of new practices (Adesina and Chianu 2002). Accordingly, the sign of this variable is not clear a prior.

4.1.4.3 Characteristics of the farm household

Dependence on other crops

Dependence on other crops indicates the number of activities other than citrus cultivation on the farm, and simply indicates farm diversification. Gillespie et al. (2007) and Fernandez-Cornejo et al. (1994) found that more diversified producers are likely to adopt BMPs as the adoption could potentially offer benefits to other farm business sections. This study thus hypothesises that dependence on other crops is positively associated with BMP uptake.

Level of farming experience

The association between experience and BMP adoption is not clear. Nyaupane and Gillespie (2009) found that farming experience is positively associated with adoption rate. Greater experience could simply mean a better knowledge in farm management, and more accurate assessment of benefits from BMP uptake (Herath and Takeya 2003). On the other hand, more experienced farmers, also older farmers, have shorter planning horizons, and thus are less likely to adopt new conservation practices (Ribaudo et al. 1999; Traore et al. 1998). Further, a belief in traditional farming practices could possibly outweigh new technology as experience increases (Herath and Takeya 2003). Accordingly, the expected sign for this variable is uncertain a priori.

Health state

Provided economic factors are not a driving force in BMP adoption, human capital variables such as health increase the adoption likelihood of conservation practices (Traore et al. 1998). Poor health could shorten planning horizons and deter normal decision-making (Rahm and Huffman 1984). Thus, it is hypothesised that a healthy farmer is more likely to adopt BMPs.

4.1.4.4 Farm business structure

Farm size

Farm size is positively associated with the adoption of new conservation practices. Smaller farmers face large fixed costs, transaction costs, and information costs, and thus these reduce the tendency to adopt new practices (Larson et al. 2007; Zubair and Garforth 2006; Beedell and Rehman 2000; Fernandez-Cornejo et al. 1994; Earle et al. 1979). On the other hand, smaller farmers may be able to adapt faster to new practices (Feder et al. 1985; Greene 1973). According to Nyaupane and Gillespie (2009), farm size has different effects on the adoption rate, depending on the characteristics of BMPs. Accordingly, a priori may not be suitable.

Location

BMP that is developed for one particular setting may not suitable or may cause damage if applied in another setting. Farmers will be unwilling to adopt a practice that is inappropriate for their land (Ribaudo et al. 1999). As they are twelve BMPs proposed in this study, a priori may not be suitable.

Proximity to a water course

As BMPs are initially introduced to capture the problem of water quality degradation caused by traditional farming practices, farms having a stream or drainage running through are more likely to adopt BMPs (Gillespie et al. 2007; Rahelizatovo 2002).

Soil type

Soil characteristics, such as natural fertility, drainage efficiency, and erosion susceptibility potentially influence BMP adoption. Farms with good soil quality would achieve better effects through an adoption of new conservation practices (Zhou et al. 2008; Rahm and Huffman 1984), thus it is hypothesised that a farm with poorer soil condition is less likely to adopt BMPs

Family labour

Family members provide unpaid farm labour to the enterprise. Gillespie et al. (2007) and Fernandez-Cornejo et al. (1994) found that family labour supply is positively associated with the adoption of labour-intensive practices.

Land ownership

Land ownership reflects planning horizons and risk aversion. It increases incentives to adopt more eco-friendly practices by lengthening time horizons and the share of benefits accruing to the adopter (Herath and Takeya 2003). An association between land tenure and adoption varies by types of landholding and the nature of the innovation. The land owner is likely to adopt new practices if the innovations require investment tied to the land (Zubair and Garforth 2006; Sheikh et al. 2003; Soule and Tegene 2000). Conversely, given the same condition, the tenant is less likely to adopt new practices because the perceived benefits from adoption may not accrue to them (Nyaupane and Gillespie 2009; Fernandez-Cornejo et al. 1994). Oates (2006) found that short term rental contracts in Thailand discouraged farmers from an investment in new technology because they cannot apply for bank credit[11].

Household income

Information about new technology is not costless. Further, adoption costs such as initial investment cost, and conversion costs may be high. As such, households with greater income are more likely to adopt new conservation practices (Rodriguez et al. 2009; Gillespie et al. 2007; Sheikh et al. 2003; Ribaudo et al. 1999). Thus, it is expected that household income is positively associated with BMP adoption.

Household debt

Previous investment, such as initial investment and supporting materials is directly linked to household debt. Normally, farmers are able to repay their loans after the first harvest. This kind of commitment limits farmers' choice (Oates 2006). Thus, it is hypothesised that household debt is negatively associated with BMP adoption.

Two other variables further included in this study are the contribution of full-time workers and the contribution of part-time workers in farm activity.

[11] Land title is needed to guarantee bank credit

Full time workers

It is hypothesised that the number of full time workers could influence the adoption of a particular practice. With high rates of full time working in the field, it is expected that the adoption of time- and management- intensive technology increases.

Part time workers

It is hypothesised that farms which rely on a high rate of part time workers are unlikely to adopt high-commitment practices, such as BMPs in Good Husbandry category.

4.1.4.5 Social milieu

Membership of farmers' conservative group

Being a member of a farmer association can ensure access to timely and accurate information (Herath and Takeya 2003). Member of a conservative group is also likely to take conservation advice and tends to think of the long-term productivity of their farm (Beedell and Rehman 2000). Accordingly, it is expected that membership status is positively associated with BMP adoption.

Access into government advisory services

State agencies are responsible for transferring agricultural knowledge and information to farmers. A local extension service office is located in each district. A mobile unit providing prompt technical service to farmers is also available. Literature shows that the number of times producers meet with state extension service personnel enhances the rate of BMP adoption (Herath and Takeya 2003; Henning and Cardona 2000). Thus, it is hypothesised that the accessibility level, from easy to difficult, is negatively associated with BMP adoption.

Access into other sources of advisory services

Besides information from the state agency, farmers also rely on information from a network of providers such as chemical dealers, and input supply retailers. Provided technical assistance is easily received from this network, farmers are likely to adopt new conservation practices (Feather and Cooper 1995). Empirical studies present a positive relationship between the availability of information and the uptake of conservation practices (Gillespie et al. 2007; Traore et al. 1998). Thus, it is hypothesised that the accessibility level, from easy to difficult, is negatively associated with BMP adoption.

4.1.5 Questionnaire development

4.1.5.1 First draft questionnaire

The first draft questionnaire was constructed and included: 1) an open space for filling the most three preferable BMPs in priority order; 2) a set of multipoint-scale questions including direct measures and indirect measures reflecting thirteen psychological variables; and 3) a set of additional variables.

4.1.5.2 Feedback from experts

The first draft questionnaire was presented at international conferences[12]. Feedback from conference participants was taken into account. The questionnaire was redrafted to make its layout clearer, and question items were rephrased to make it more concise.

4.1.5.3 Piloting the questionnaire

Five participants were asked to complete the questionnaire and comment on the difficulty and clarity of the questions. A second draft was also written in consultation with a research team experienced in interviews with local people. Responses led to minor changes in wording and formatting (i.e. sequence and layout), and thus a final questionnaire was constructed (Annex 5).

4.1.6 Fieldwork administration

4.1.6.1 Sampling method and sample size calculation

A simple random sampling scheme was applied for small- to medium- scale farm households in the Ping river basin. This procedure gives each member of the population an equal chance of being chosen. The procedure is a sampling without replacement (Newbold 1995). The

[12] Two international conferences are 1) ‘Integrating Conservation in the Upland Agriculture in Southeast Asia’, International Agroforestry Education Conference, 24-26 October 2007, Chiang

question is how many sample observations are needed. According to Bartlett et al. (2001), the determination of sample size depends on which type of variables play a primary role in data analysis. The construction of TPB questionnaire requires a multipoint scale measurement, which is classed as continuous data. Therefore, the continuous sample size formula (equation 2) was used as follows:

$$n_0 = \frac{(t)^2 \times (s)^2}{(d)^2} \qquad \text{(Equation 2)}$$

where;

t = value for selected alpha level of .025 in each tail = 1.96 (the alpha level of .05 indicates the level of risk the researcher is willing to take that true margin of error may exceed the acceptable margin of error)

s = estimate of standard deviation in the population = 1.167 (estimate of variance deviation for seven point scale calculated by using 7 [inclusive range of scale] divided by 6 [number of standard deviations that include almost all (approximately 98%) of the possible values in the range])

d = acceptable margin of error for mean being estimated = .21 (number of points on primary scale times acceptable margin of error; seven-point scale times acceptable margin of error of .03)

There is a population of 439 households in upstream area and that of 1,163 households in downstream area (Table 4-4).

Mai, Thailand; and 2) 'The 28th Biannual Workshop', held by the Economy and Environment Program for Southeast Asia, 13-16 November 2007, Kuala Lumpur, Malaysia.

Table 4-4: Sampling frame

Provinces[1]	Reported of cultivated district[2]	No. of Households[2]	Cultivation area (rai)[2]
Upstream			
Chiang Mai	17	345	4,340
Mae Hong Son	4	45	229
Tak	-	-	-
Lam Pang	4	45	104
Lam Phun	1	4	24
Sub-total	***26***	***439***	***4,697***
Downstream			
Kampangpeth	7	795	13,813
Nakorn Sawan	3	368	5,122
Sub-total	***10***	***1,163***	***18,935***
Total	**36**	**1,602**	**23,632**

Sources:
(1) derived from GIS data, Office of Project Management, Royal Irrigation Department (RID 2007)
(2) DOAE Information Centre, Department of Agricultural Extension (DOAE 2007a)

The required sample size for each area is:

$$n_0 = \frac{(1.96)^2 \times (1.167)^2}{(7 \times .03)^2} = 118$$

However, since this sample size exceeds 5% of the population (439 $\times$ .05 = 21.95, and 1,163 x .05 = 58.15), Cochran (1977)'s correction formula (equation 3) is used to calculate the final sample size.

$$n_1 = \frac{(n_0)}{[1 + (n_0 / population)]} \qquad \text{(Equation 3)}$$

where;

Population size = 439 for upstream area and 1,163 for downstream area

n_0 = required return sample size according to Cochran's formula = 118

n_1 = required return sample size because sample > 5% of population

n_{1U} = the minimum returned sample size for the upstream area = 93

n_{1D} = the minimum returned sample size for the downstream area = 107

4.1.6.2 Data collection

Sample size

The survey administration was split into two periods. The first survey was conducted from December 2007 to January 2008. The second survey was from June to August 2008. The total sample size was 218 (13.61% of population). Of those, 126 are from the upstream area and 92 are from the downstream area. The numbers of interviews are shown in Table 4-5, and the distribution of sample is illustrated in Figure 4-4.

Table 4-5: Sample distributions and interviews achieved by area

Provinces	Target number of interviews	Participants showing at the interview venue	Unusable responses			Interviews achieved
			Refuse to participate	Incomplete answer	Inconsistence in Psychological test*	
Upstream						
Chiang Mai	70	87	1	1	2	83
Mae Hong Son	10	12	-	-	1	11
Lam Pang	20	34	-	1	1	32
Sub-total	***100***	***133***	***1***	***2***	***4***	***126***
Downstream						
Kampangpeth	95	84	1	5	1	77
Nakorn Sawan	20	17	2	-	-	15
Sub-total	***115***	***101***	***3***	***5***	***1***	***92***
Total	**215**	**234**	**4**	**7**	**5**	**218**

Note: * consistency in psychology tests refers to reliability whether a researcher gets the same result across a range of measurement. To assess the responses, the TPB-based questionnaire was designed to have two different questions that tested the same construct. For example, two questions (questions 10 and 19: see Annex 5) were used to measure an attitude towards the notion that BMP adoption could protect environment. A response containing inconsistent results was rejected as this showed that a participant may not carefully answer, thus leading to bias and inaccuracy of data interpretation.

The target for the upstream area was 100 households. The appointments with farmers were made through the Tambon (sub-district) Administrative Organisations (TAOs) and agricultural extension agencies at district level. A total of 133 participants came for interview but one refused to participate in the interview. Two participants gave incomplete answers about household income, and four participants gave inconsistent answers in the psychological section. Therefore, there were 216 interviews with upstream farmers.

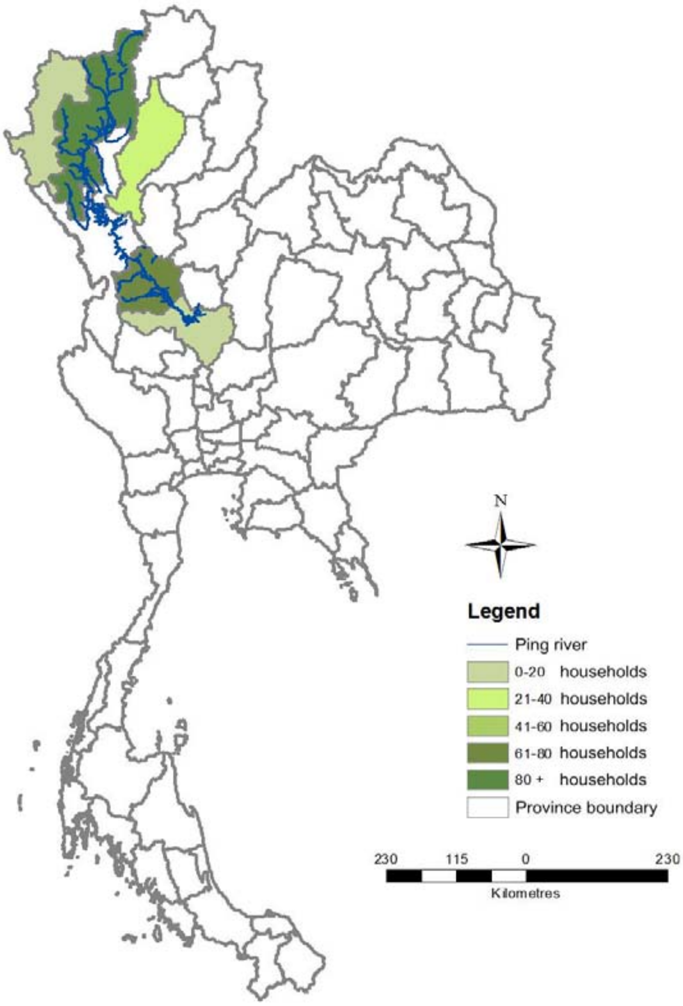

Figure 4-4: Distribution of sample by area

The target for the downstream area was 115 households. The appointments with citrus farmers were also made through the TAOs and agricultural extension agencies at district level. Only 101 participants came for interview, and this number was less than targeted. Further, three participants refused to complete the interviews. Five participants gave incomplete answers and one participant gave inconsistent answers in the psychological section. In total, there were 92 interviews with downstream households.

Flow of information and tasks for participants

A team leader started the interviews by describing the role of the watershed and its natural services. This was followed by a description of the impacts from nonpoint source pollution, possibly generated by citrus production. The scientific information regarding water quality in the Ping river basin, compared to other river basins nationwide, was also demonstrated to participants through a water quality map. Then, twelve BMPs were demonstrated to participants (see illustrations in Annex 6). Participants were informed that they were free to ask the research team any questions before, during and after the survey.

Task 1: Adoption intention and rank-ordering

Participants were presented with pictures of twelve BMPs together with implementation details, expected environmental benefits from adoption, and cost components of each BMP. Then, they were asked to make a decision on whether to adopt that technique on their farm. Provided behaviour is voluntary and conscious, BMP is selected based on the anticipated consequences (i.e. need satisfaction, goal achievement) that provide positive consequences, and avoid negative outcomes (Olson and Reynolds 2001). It is at this stage that participants were asked to select only three BMPs that they wanted to use at their farms. Next, participants were asked to rank these three BMPs in priority order.

Task 2: Personal interview

Participants who had already selected their three practices were interviewed personally by an enumerator. First, they were asked about their background, such as demographic data. Then, they were asked to complete a set of multipoint-scale questions reflecting psychological variables. Participants with literacy were asked to complete this section by themselves. However, an enumerator was provided to respond promptly if difficulties arose. Participants who were unable to read were assisted by an enumerator.

Communication management

Misunderstanding could happen during the flow of information. On one hand, a message from the research team could confuse and mislead participants, and may cause them to act in unintended ways (Whittington 2004). Moreover, a warm-glow effect (Andreoni 1990)[13] could be inspired because citrus farmers were asked about hypothetical outcomes. One

[13] When people make donations to privately provided public goods, there may be other factors (i.e. to win prestige, respect, friendship, to avoid scorn, to receive social acclaim) influencing their decision other than altruism.

attempt to reduce the bias in hypothetical commitment is a cheap talk script (Carlsson et al. 2005; Cummings and Taylor 1999). Participants were informed that the study will be used solely for the purpose of research, that it is important that participants should carefully consider when answering, and that their answers will be confidentially treated. A serious response is likely when participants are reminded of the consequences of their actions (Bulte et al. 2005).

On the other hand, information from the participants to the research team was filtered through the enumerators. Thus, prior to the fieldwork, enumerators were trained to ensure that they understood the object of the survey and basic technical aspects contained in the twelve intention simulations. As suggested by Whittington (2002), pairs of enumerators role-played an entire questionnaire in front of the group of the survey team. They then discussed the mock interview and any problems that arose. The team leader stepped in to assist and guide on how to handle particular problems. It is expected that during the survey all enumerators are able to respond in a knowledgeable and informed manner.

Ethical considerations

During the fieldwork, participants were notified of aims, methods, anticipated benefits and potential hazards of the research. They were informed of the voluntary nature of the interview and their right to refuse to be interviewed or to terminate interviews in progress.

4.2 Descriptive Results

This section provides summarised information and comprises two sub-sections. First, descriptive data are presented based on characteristics of farmers in terms of both socio-economic and psychological constructs. This sub-section also presents the frequency of BMP selected as 1st, 2nd, and 3rd option according to farm location. The following sub-section offers insights into the differences in the sample means of upstream and downstream farmers. A Mann-Whitney test is also employed to compare differences in farm and farmer characteristics. Prior to the analysis, it should be noted here that farm location is considered as an importantly distinctive difference amongst Thai citrus farmers. Particularly, a spatial difference contributes to a different style of farm management and land use, and thus could possibly lead to a difference in farmers' attitudes and preferences towards BMP adoption. Accordingly, the further analysis will be done on the basis of farm location.

4.2.1 Descriptive statistics

4.2.1.1 Characteristics of citrus farmers

The statistical analysis includes 218 farmers of which 126 (58%) are from the upstream area and 92 (42%) are from the downstream area. The characteristics of the sample are presented in Table 4-6.

Table 4-6: Characteristics of citrus farmers

Variables	Upstream		Downstream		Overall	
	(n=126)	(%)	(n=92)	(%)	(n=218)	(%)
Socio-demographics of farmer						
Age (years)						
Less than 30	19	15.1	3	3.3	22	10.1
30.1 - 40	23	18.3	25	27.2	48	22.0
40.1 - 50	32	25.4	28	30.4	60	27.5
50.1 - 60	30	23.8	26	28.3	56	25.7
More than 60	22	17.5	10	10.9	32	14.7
Mean (S.D.)	*47.1(13.9)*		*47.2 (10.6)*		*41.2(12.6)*	
Education level						
Less than high school	77	61.1	55	59.8	132	60.6
High school and over	49	38.9	37	40.2	86	39.5
Gender						
Male	90	71.4	68	73.9	158	72.5
Female	36	28.6	24	26.1	60	27.5
Characteristics of the farm household						
Farm experiences (years)						
Less than 15	91	72.2	83	90.2	174	79.8
15 or over	35	27.8	9	9.8	44	20.2
Mean (S.D.)	*12.0(10.2)*		*8.4(8.9)*		*10.5(9.8)*	
Dependency of other crops						
Yes	103	81.8	60	65.2	163	74.8
No	23	18.3	32	34.8	55	25.2
Health problem retarding farming activities						
Yes	21	16.7	30	32.6	51	23.4
No	105	83.3	62	67.4	167	76.6

Variables	Upstream		Downstream		Overall	
	(n=126)	(%)	(n=92)	(%)	(n=218)	(%)
Structures of the farm business						
Land ownership						
Own land	103	81.8	79	85.9	182	83.5
Under others	23	18.3	13	14.1	36	16.5
Farm size (rais)						
Less than or equal 5	42	33.3	4	4.4	46	21.1
5.01 - 10	39	31.0	28	30.4	67	30.7
10.01 - 20	24	19.1	27	29.4	51	23.4
20.01 - 50	13	10.3	18	19.6	31	14.2
More than 50	8	6.4	15	16.3	23	10.6
Mean (S.D.)	*17.0(29.0)*		*39.4(97.5)*		*26.4(67.8)*	
Location of farm						
Upstream	126	100.0	-	-	126	57.8
Downstream	-	-	92	100.0	92	42.2
Farm resource endowments						
- Stream						
Yes	75	59.5	80	87.0	155	71.1
No	51	40.5	12	13.0	63	28.9
- Soil type						
Clay	22	17.5	42	45.7	64	29.4
Loam	30	23.8	6	6.5	36	16.5
Sandy and others	74	58.7	44	47.8	118	54.1
Labour management in farm workload						
- Contribution of family labour (%)						
Less than or equal 50	83	65.9	79	85.9	162	74.3
More than 50	43	34.1	13	14.1	56	25.7
- Contribution of part time worker (%)						
Less than or equal 50	58	46.0	29	31.5	87	39.9
More than 50	68	54.0	63	68.5	131	60.1
- Contribution of full time worker (%)						
Less than or equal 50	126	100.0	91	98.9	217	99.5
More than 50	-	-	1	1.1	1	0.5
Household income (THB/rai)						
Less than median value	47	37.3	62	67.4	109	50.0
Equal or more than median value	79	62.7	30	32.6	109	50.0
Mean (S.D.)	*33,046.7 (51,936.2)*		*16,614.5 (22,780.7)*		*26,112.0 (42,867.0)*	
Median value					*13,166.7*	
Household debt (THB/rai)						
Less than median value	82	65.1	26	28.3	108	49.5
Equal or more than median value	44	34.9	66	71.7	110	50.5
Mean (S.D.)	*21,073.9 (41,555.0)*		*42,652.7 (79,785.9)*		*30,180.6 (61,468.2)*	
Median value					*12,000.0*	

Variables	Upstream		Downstream		Overall	
	(n=126)	(%)	(n=92)	(%)	(n=218)	(%)
Social milieu						
Membership of farmer association						
Yes	66	52.4	70	76.1	136	62.4
No	60	47.6	22	23.9	82	37.6
Access to government advisory services						
No need for services	40	31.8	45	48.9	85	39.0
Easy or not so difficult	50	39.7	34	37.0	84	38.5
Difficult or not so easy	36	28.6	13	14.1	49	22.5
Access to other advisory services						
No need for services	26	20.6	1	1.1	27	12.4
Easy or not so difficult	97	77.0	86	93.5	183	83.9
Difficult or not so easy	3	2.4	5	5.4	8	3.7

Farmer socio-demographics

The average age of upstream farmers is 47.1 years and that of downstream farmers is 47.2 years. Both have an education level less than high school and one-third are male.

Farm household characteristics

On average, farmers in the upstream area have longer experience in farming than those in the downstream area. Most farmers depend on other cash crops, and indicate no health problems in citrus farming.

Structure of the farm business

Most of farmers are land owners. The average farm size of upstream farms is 17.0 rais, and that of downstream farms is 39.4 rais. It should be noted that the samples contain only small- to medium-scale farmers. Therefore, a caution should be taken when interpreting this data and making any further analysis. In this study, the survey could not carry out with large-scale farmers because of a time limitation and a difficulty to arrange a meeting with either owners or farm managers.

Most farms are situated by streams or have a stream running through. Soil type in upstream areas is typically sandy, while in downstream areas soil is proportionately clay and sandy. Overall, the farm workload mainly relies on part-time workers. The average income of upstream farms is higher than downstream farms, while the average debt of upstream farms is lower than downstream farms.

Social milieu

Overall, most farmers are members of farmer associations. There is little complaint about difficulty accessing either government advisory services or other sources of information.

Descriptive statistics of farmers' psychological characteristics are illustrated in Table 4-7. A direct measure was scaled from 1 to 7, while an indirect measure was a summated scale and was derived from the personal belief score (ranged from 1 to 7) weighted by the personal evaluation score (ranged from -3 to +3). Thus, for the indirect measure the lowest summated score is -21 (i.e. 7 times -3), and the highest summated score is +21 (i.e. 7 times +3). For both measures the higher the score, the more likely the adoption intention.

Table 4-7: Psychological characteristics of citrus farmers

Variables	**Upstream (n = 126)**		**Downstream (n= 92)**		**Overall (n = 218)**	
	Mean	**(S.D.)**	**Mean**	**(S.D.)**	**Mean**	**(S.D.)**
Direct measures						
Attitudes						
Overall adopting BMPs is BAD(1[a]) vs. GOOD (7)	4.1	(2.6)	2.6	(2.2)	3.5	(2.5)
Overall adopting BMPs is WORTHLESS(1) vs. USEFUL(7)	6.1	(1.6)	6.3	(1.2)	6.2	(1.5)
Overall, adopting BMPs is the WRONG thing to do(1) vs. RIGHT thing to do(7)	4.2	(2.5)	2.7	(2.2)	3.6	(2.5)
Overall, adopting BMPs is UNPLEASANT(1) vs. PLEASANT(7) for me	4.2	(2.5)	2.8	(2.1)	3.6	(2.4)
Subjective norms						
Important people think that I should NOT(1) vs. SHOULD(7) adopt BMPs	3.8	(2.5)	5.0	(2.3)	4.3	(2.4)
It is expected for me that I should adopt BMPs, DISAGREE(1) vs. AGREE(7)	5.5	(1.7)	5.7	(1.8)	5.6	(1.7)
I feel under social pressure to adopt BMPs, DISAGREE(1) vs. AGREE(7)	5.0	(2.1)	4.7	(2.2)	4.8	(2.1)
Important people want me to adopt BMPs, DISAGREE(1) vs. AGREE(7)	5.5	(1.8)	5.5	(1.8)	5.5	(1.8)
Perceived behavioural control						
I am confident that I could adopt BMPs if I want to, DISAGREE(1) vs. AGREE(7)	5.8	(1.6)	6.0	(1.5)	5.9	(1.5)
For me, to adopt BMPs is DIFFICULT(1) vs. EASY(7)	4.4	(2.1)	3.9	(1.7)	4.2	(2.0)
The decision to adopt BMPs is beyond my control[b], AGREE(1) vs. DISAGREE(7)	4.5	(2.3)	4.2	(2.3)	4.3	(2.3)
Adopt BMPs or not is entirely up to me, DISAGREE(1) vs. AGREE(7)	4.4	(2.4)	5	(1.9)	4.8	(2.3)

Notes:
(1) [a]Number represents score
(2) [b]The negative item was reversed score
(3) [c]Indirect measure score is ranged from -21.0 to +21.0

Variables	Upstream (n = 126)		Downstream (n= 92)		Overall (n = 218)	
	Mean	(S.D.)	Mean	(S.D.)	Mean	(S.D.)
Indirect measures[c]						
Attitudes						
Reduced production cost	12.6	(7.9)	13.1	(8.4)	12.8	(8.1)
Environmental protection	17.2	(6.0)	17.7	(5.8)	17.4	(5.9)
Watershed services gained	15.4	(7.3)	16.3	(6.5)	15.7	(7.0)
Greater commitment[b]	4.4	(8.7)	0.9	(8.9)	2.9	(8.9)
Subjective norms						
Consumers	13.2	(8.8)	13.3	(9.5)	13.3	(9.1)
Government	12.0	(8.3)	11.5	(9.7)	11.8	(8.9)
Agricultural supply retailer	4.4	(9.8)	4.7	(9.6)	4.5	(9.7)
Neighbours	5.8	(10.2)	4.6	(10.0)	5.3	(10.1)
Perceived behavioural control						
Affordable	11.0	(7.9)	9.0	(10.2)	10.1	(9.0)
Return	7.2	(7.0)	5.4	(8.4)	6.4	(7.6)
Knowledge	10.2	(8.4)	9.0	(8.6)	9.7	(8.5)
Farmer association	9.5	(10.6)	7.5	(10.9)	8.6	(10.7)
Potential market	11.1	(9.8)	9.9	(9.7)	10.6	(9.7)

Note:
(1) [a]Number represents score
(2) [b]The negative item was reversed score
(3) [c]Indirect measure score is ranged from -21.0 to +21.0

In general, upstream farmers hold more positive attitudes toward BMP uptake than downstream farmers. Upstream farmers view the adoption as more ‘good’, ‘right’, and ‘pleasant’ than downstream farmers (Figure 4-5). Upstream farmers appear to be less influenced by their social pressures. They present relatively low agreement with the statement ‘important people think that I should adopt BMPs’ (Figure 4-6). Downstream farmers are not confident in their abilities to adopt BMPs, and they express difficulty in performing the BMP adoption (Figure 4-7).

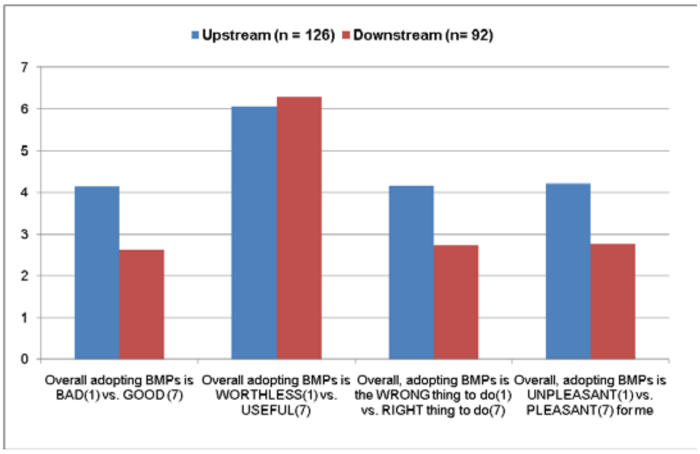

Figure 4-5: Mean of attitude direct measures by location; scores are ranged from 1 to 7

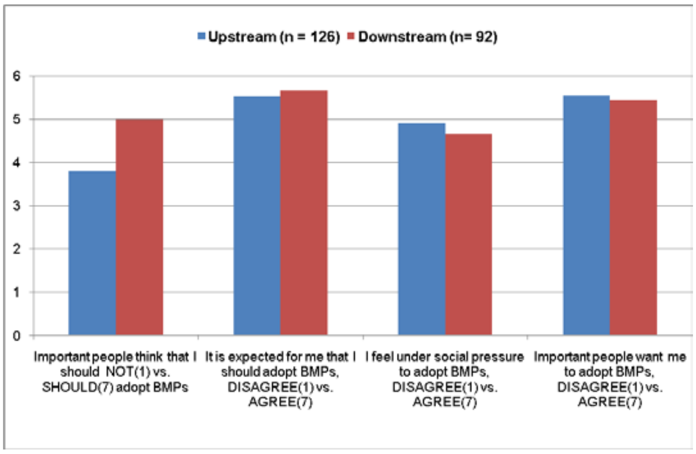

Figure 4-6: Mean of subjective norm direct measures by location; scores are ranged from 1 to 7

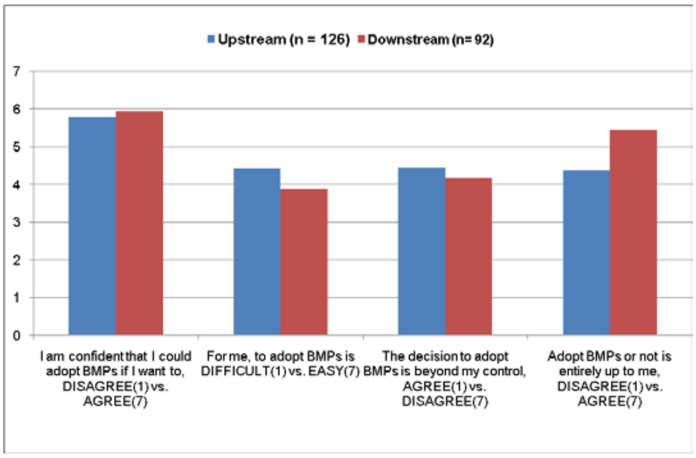

Figure 4-7: Mean of perceived behavioural control direct measures by location; scores are ranged from 1 to 7

Means of indirect measures are illustrated in Figure 4-8. Overall, results suggest an attitude that BMP adoption could enhance environmental protection. Farmers also perceive that BMP adoption will result in improved watershed services, and reduced production costs. Further, farmers perceive that BMP adoption will impose a greater commitment to farm management.

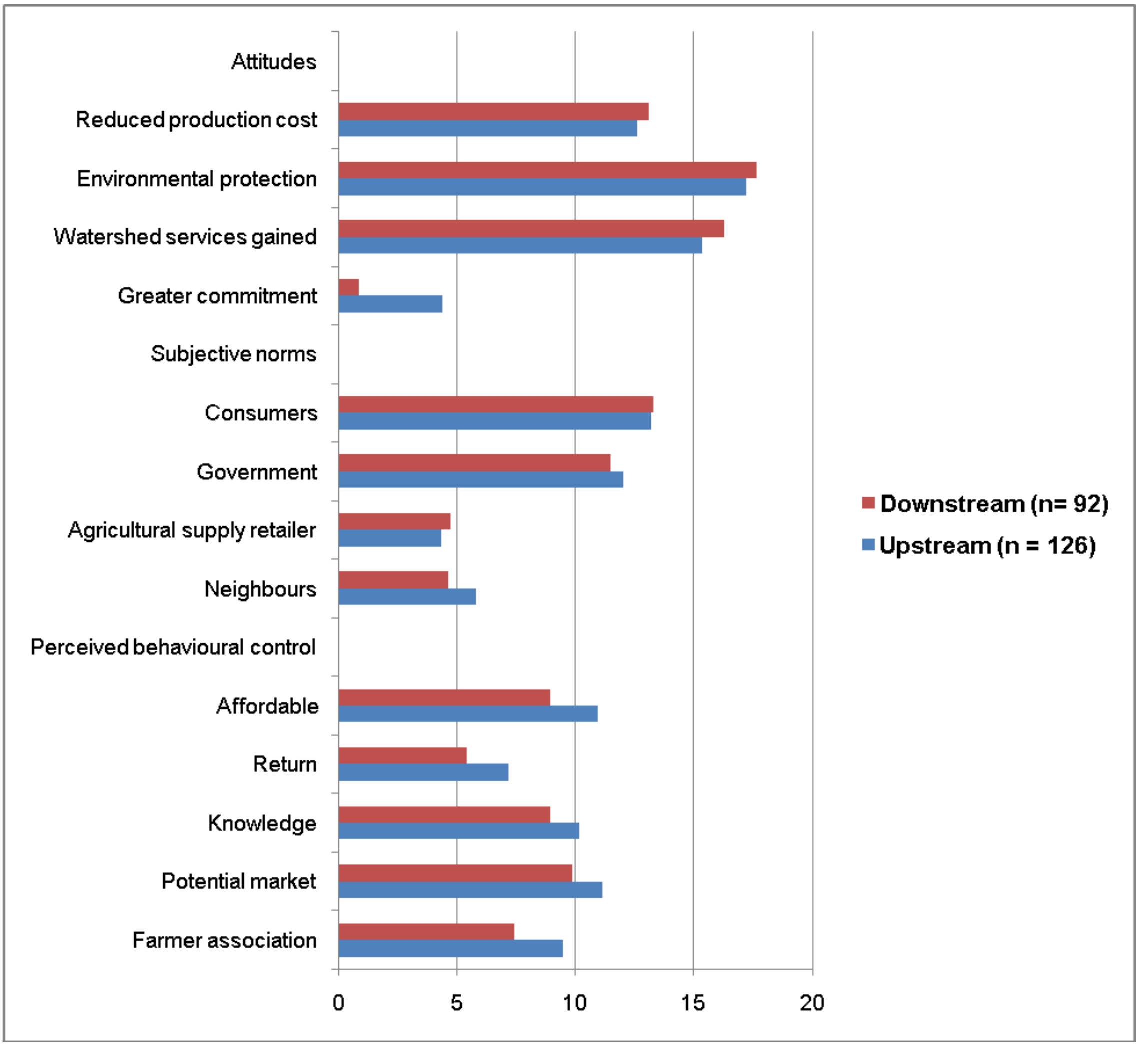

Figure 4-8: Mean of indirect measures

Notes:
(1) The negative item (i.e. greater commitment) was reversed score
(2) Scores are ranged from -21.0 to +21.0

Of all the social referents, consumers are the most important influences when farmers make adoption decisions. This is followed by the state government, neighbours and agricultural supply retailers. The strongest perceived facilitator to adopt BMPs is the existing of market for eco-friendly products. This is followed by affordability, knowledge, farmer associations and perceived returns.

4.2.1.2 BMP selection

Overall, Good Husbandry is the functional category most preferred by both upstream and downstream farmers (72.0%). This is followed by Structural Practice (17.0%) and Vegetative Practice (11.0%). Details are presented in Table 4-8. Of all the practices, the most selected adoption choice is soil analysis for which more than one-third of farmers voted (35.3%). Additionally, it is the adoption choice most highly voted by both farmer groups (35.7% for upstream farmers and 34.8 8% for downstream farmers). Discussion with farmers after the interviews revealed a few reasons for the preference. First, farmers are faced with an increase in input prices especially fertiliser and chemicals. The adoption of this BMP results in a reduction of fertiliser application and simply means a decreased production cost. Second, some farmers perceived on-farm soil deterioration due to a continuous high rate of fertiliser application. They are afraid that this may lead to a reduction in farm profit, and seek alternatives. Third, soil analysis is the BMP that can be adopted in any farm terrain. That is, it is not a site-specific BMP, and thus there is no topographic barrier.

Table 4-8: Selection of BMPs

Practices	Upstream			Downstream			Overall		
	Frequency (n=126)	%	Order	Frequency (n=92)	%	Order	Frequency (n=218)	%	Order
Good Husbandry									
Scheduling water structure	10	7.9	4	25	27.2	2	35	16.1	2
Apply herbicide within tree canopy	20	15.9	2	6	6.5	6	26	11.9	3
Basic restrictions for pesticide application	16	12.7	3	3	3.3	8	19	8.7	5
Soil analysis	45	35.7	1	32	34.8	1	77	35.3	1
Total	91	72.2		66	71.7		157	72.0	
Vegetative Practices									
Vegetative cover	6	4.8	7	6	6.5	6	12	5.5	7
Mulching	4	3.2	8	7	7.6	4	11	5.1	8
Vegetative buffer strip	-	-	12	-	-	12	-	-	12
Grassed waterway	1	0.8	10	-	-	12	1	0.5	10
Total	11	8.7		13	14.1		24	11.0	
Structural Practices									
On-site retention storage	11	8.7	6	3	3.3	8	14	6.4	6
Terracing	2	1.6	9	-	-	12	2	0.9	9
Mix-load and wash-down site	11	8.7	6	10	10.9	3	21	9.6	4
Riparian setbacks	-	-	12	-	-	12	-	-	12
Total	24	19.1		13	14.1		37	17.0	

4.2.2 Comparative differences

A further analysis of Mann-Whitney test (M-W test) is performed to understand the differences between upstream and downstream farmers. The following comparisons employ 128 upstream farmers and 92 downstream farmers in the Ping river basin. Comparative perspectives are presented as follows.

4.2.2.1 Comparisons of farm and farmer characteristics

Differences in farm and farmer characteristics in upstream and downstream areas are as follows (Table 4-9):

1) More upstream farmers farm on their own land than downstream farmers who generally farm on rented land

2) Upstream farm size is significantly smaller than downstream

3) The number of upstream farms that has stream running through or next to it is less than that in downstream farm

4) Upstream farmers have more experience in citrus cultivation than downstream farmers

5) Upstream farmers have fewer health problems than downstream farmers

6) Upstream farmers are more dependent on other cash crops rather than citrus

7) Membership of farmers' associations in upstream area is significantly lower than downstream

8) Upstream farmers face more difficulty in accessing sources of information other than government advisory services than downstream farmers

9) Upstream farmers have lower debt than downstream farmers

Table 4-9: Mann-Whitney test of external variables

External Variables	Farm location	Mean Rank (Order)	Mean	Std. Deviation
Gender	Upstream	110.6	0.3	0.5
	Downstream	107.9	0.3	0.4
Age	Upstream	109.3	47.1	13.9
	Downstream	109.8	47.2	10.6
Education level	Upstream	105.9	1.8	1.4
	Downstream	114.4	1.9	1.3
Land ownership***	Upstream	97.2	0.9	0.4
	Downstream	126.4	1.1	0.4
Farm size (rai) ***	Upstream	88.9	16.9	28.8
	Downstream	137.7	39.4	97.5
Any stream run through farm***	Upstream	96.9	0.6	0.5
	Downstream	126.8	0.9	0.3
Soil type	Upstream	104.0	3.1	1.3
	Downstream	117.1	3.4	1.7
Past experience (years) ***	Upstream	122.2	12.0	10.2
	Downstream	92.2	8.4	8.9
Health condition**	Upstream	102.2	0.2	0.4
	Downstream	119.5	0.3	0.4
Number of family members	Upstream	102.9	2.3	1.5
	Downstream	118.5	2.6	1.4
Number of full-time workers	Upstream	109.5	1.8	7.2
	Downstream	109.5	2.5	9.6
Number of part-time workers	Upstream	103.5	8.3	14.7
	Downstream	117.7	11.8	32.1
Crop dependency**	Upstream	117.1	0.8	0.4
	Downstream	99.1	0.7	0.5
Membership of farmers' association***	Upstream	98.6	0.5	0.5
	Downstream	124.4	0.8	0.4
Access to governmental advisory services	Upstream	103.5	3.1	1.6
	Downstream	117.7	3.5	1.8
Access to other sources of information***	Upstream	119.7	2.1	1.6
	Downstream	95.6	1.3	0.7
Annual Household Income (THB)	Upstream	110.5	492,621.4	1,116,399.1
	Downstream	108.1	748,783.8	2,358,996.1
Amount of Household's Debt (THB) ***	Upstream	83.8	241,384.1	651,109.9
	Downstream	144.7	2,713,630.4	9,068,169.9

Notes: ** significant at .01 level, *** significant at .001 level

Further points to add from Table 4-9 are as follows. A steeper slope and relatively hilly terrain in the upstream area influences farm size and management style. The upstream area consists of dispersed farms, which are relatively small and regularly on the valley floor, whereas a number of large scale farms are apparent in the downstream area. The geography of the upstream area and distant farm location cause difficulty for service delivery by government agents, and thus advisory support from government is less frequent amongst upstream farmers than downstream farmers. Further, as farms in the upstream area are scattered on the valley floor, farmers do not have an incentive to rent more land. Rather, upstream farmers rely more on semi-subsistence farming[14] with crop diversification to reduce risks in income. With this management style, farm household debt in upstream areas is lower than downstream areas, and there is less incentive for farmer collaboration.

4.2.2.2 Comparisons of psychological variables

Differences in psychological characteristics of farmers in upstream and downstream areas are described as follows (Table 4-10):

Direct measures

1) Upstream farmers significantly perceive BMP adoption as better, right and pleasant thing to do than downstream farmers

2) Upstream farmers are less likely to be influenced by social pressures

3) Upstream farmers perceive BMP implementation is easier than downstream farmers

4) Upstream farmers perceive less control over the consequences of BMP adoption than downstream farmers

Indirect measures*:* Though both upstream and downstream farmers perceive that BMP adoption will impose a greater commitment to farm management, by comparison, upstream farmers see that more work is not a crucial barrier.

The significant statements from psychological measures can be jointly implied with the interpretation of the external factors mentioned above. Semi-subsistence farming in the upstream area represents more traditional farming practices, while farms in the downstream area are business-oriented farming systems, which are currently dependent on chemical application to maintain output. As such, it is clear that downstream farmers view BMP

[14] Here, semi-subsistence farming refers to the cultivation that takes place on small farms and uses simple techniques.

adoption as less good, not right, and unpleasant. Furthermore, as downstream farmers have experienced greater debt than upstream farmers they are likely to refuse adoption of BMPs that could reduce profit. On the other hand, upstream farmers perceive adopting BMPs as easier because they hold smaller farm size. Commitment to implement BMPs in a small piece of land is unlikely to deter adoption decision-making.

Differences in the importance of other people upon farmers' adoption intentions can be explained by farm location, farm goals and farmer attitudes. Evidence shows that upstream farms, which are more subsistence-oriented and located further away from market and information, are less influenced by others whereas business-oriented farms in a downstream area are likely to be influenced by others, particularly consumers. Moreover, that upstream farmers report less ability to control the consequences of BMP adoption is supported by the fact that they farm in a distant area, and thus receive less assistance and up-to-date information from government agencies.

Table 4-10: Mann-Whitney test of psychological variables

Direct Measurement	Farm location	Mean Rank (Order)	Mean	Std. Deviation
Overall, adopting BMPs is Bad vs. Good***	Upstream	124.7	4.1	2.6
	Downstream	88.7	2.6	2.2
Overall, adopting BMPs is Worthless vs. Useful	Upstream	108.3	6.1	1.6
	Downstream	111.1	6.3	1.2
Overall, adopting BMPs is The Wrong thing to do vs. The Right thing to do***	Upstream	124.6	4.2	2.5
	Downstream	88.8	2.7	2.2
Overall, adopting BMPs is Unpleasant for me vs. Pleasant for me***	Upstream	125.2	4.2	2.5
	Downstream	88.1	2.8	2.1
Important people think that I Should not vs. I Should adopt BMPs***	Upstream	96.2	3.8	2.5
	Downstream	127.7	5.0	2.3
It is expected for me that I should adopt BMPs .. Disagree vs. Agree	Upstream	105.6	5.5	1.7
	Downstream	114.9	5.7	1.8
I feel under social pressure to adopt BMPs .. Disagree vs. Agree	Upstream	112.6	4.9	2.1
	Downstream	105.3	4.7	2.2
Important people want me to adopt BMPs ... Disagree vs. Agree	Upstream	110.6	5.5	1.8
	Downstream	108.1	5.5	1.8
I'm confident that I could adopt if I wanted to ... Disagree vs. Agree	Upstream	107.0	5.8	1.6
	Downstream	113.0	6.0	1.5
For me, to adopt BMPs is Difficult vs. Easy*	Upstream	117.6	4.4	2.1
	Downstream	98.4	3.9	1.7
The decision to adopt BMPs is beyond my control .. Disagree vs. Agree	Upstream	113.3	4.5	2.3
	Downstream	104.3	4.2	2.3
Adopt BMPs or not is entirely up to me ... Disagree vs. Agree**	Upstream	98.1	4.4	2.4
	Downstream	125.1	5.5	1.9

Indirect Measurement	Farm location	Mean Rank (Order)	Mean	Std. Deviation
Reduced production cost	Upstream	106.9	12.6	7.9
	Downstream	113.0	13.1	8.4
Environmental protection	Upstream	107.4	17.2	6.0
	Downstream	112.3	17.7	5.8
Gain from watershed service	Upstream	106.4	15.4	7.3
	Downstream	113.7	16.3	6.5
Greater commitment**	Upstream	120.4	4.4	8.7
	Downstream	94.5	0.9	8.9
Consumers	Upstream	108.2	13.2	8.8
	Downstream	111.3	13.3	9.5
Government	Upstream	109.5	12.0	8.3
	Downstream	109.6	11.5	9.7
Agricultural supply shop	Upstream	108.7	4.4	9.8
	Downstream	110.6	4.7	9.6
Neighbours	Upstream	111.6	5.8	10.2
	Downstream	106.7	4.6	10.0
Affordability	Upstream	114.2	10.9	7.9
	Downstream	103.0	9.0	10.2
Return	Upstream	115.8	7.2	7.0
	Downstream	100.9	5.4	8.4
Knowledge	Upstream	113.3	10.2	8.4
	Downstream	104.4	9.0	8.6
Farmer association	Upstream	114.5	9.5	10.6
	Downstream	102.6	7.5	10.9
Potential market	Upstream	113.4	11.1	9.8
	Downstream	104.2	9.9	9.7

Note: * significant at .05 level, ** significant at .01 level, *** significant at .001 level

According to Guagnano et al. (1995), psychological factors such as attitude and external conditions act jointly to influence behaviour. The M-W test could only highlight how attitudes and characteristics of upstream and downstream farmers differ, but it could not define what constitutes such differences. There might be a possibility that psychological and external factors work together to induce adoption, or external factors may contribute to the strength (or weakness) of attitude-induced behaviour. Nevertheless, this is not the main focus of this thesis, and there is room for future study in the context of the relationship between psychological and external factors influencing adoption decision. The next section presents the summary of this chapter.

4.3 Summary

Farmers' decision-making regarding adoption of new innovations and agri-environmental policies has received considerable attentions over many years. Adoption of new innovation is influenced by a variety of factors, and for this reason the study of significant variables explaining the decision is of interest to government. Traditional agricultural economics assumes that farmers make decisions to maximise their utility. However, behaviour is the consequence of a complex integration between socio-economic and psychological factors. As such, a utility approach to understand decision-making has been supplemented by an increasing input from psychology.

This study is developed based on a theoretical framework rooted in social psychology complemented with variables derived from economic theory. From a theoretical perspective, these empirical findings emphasise the relevance of combining theoretical insights from different disciplines in adoption studies. The TPB is employed to investigate factors that influence farmers' decisions to adopt twelve BMPs in citrus farms. TPB is an expectancy-value model, which has an ability to predict and to explain human behaviour by postulating that behaviour is predicted by intention to perform that behaviour. Through the use of statistical methods, the TPB provides a distinct process to show the relative importance of the proposed determinants of intention, and to investigate which attitudes influence behaviour. Furthermore, external variables are allowed to be included in the model so as to increase predictive power. Thus, the TPB can increase our understanding of farmers' beliefs for policy making.

This chapter mainly focuses on the presentation of descriptive data. Descriptive data is easily understood and it is not too technical, compared to inferential statistics. With a validity and reliability of information collected from the surveys, the results provide supporting data for policymakers by describing patterns and general trends in a data set. For example, the descriptive data illustrates the characteristics of farmers and their farm environment. Further, the TPB application shows that farmers in upstream and downstream areas differ in their evaluative measures of BMP adoption. Both are significantly different in their belief-based measures relating to attitudes towards BMP adoption. Other than differences in their latent psychological variables, both farmer groups also differ in their past experience, dependency on other crops, health state, farm size, stream condition, land ownership, household debt, membership of farmers' associations and access to information sources. Furthermore, an investigation of farmers' preference towards BMP showed that the most preferred BMP is soil analysis, which is a test of organic matters and application of organic fertiliser to match with crops' need.

Overall, the results in this chapter provide an understanding of the nature of citrus farmers in the Ping river basin, and suggest which BMPs are in the farmers' interests. This descriptive data is useful in presenting quantitative data in a manageable form. However, its main limitations are that the results could not be extrapolated to a general population, and the fact that the results could not identify a cause-effect relationship in farmers' behaviours. Rather, this descriptive data will provide basic information for further investigations of variables influencing BMP adoption, and this will be undertaken in the next chapter.

5 OBSERVATION OF STATED ADOPTION INTENTIONS

This chapter aims to investigate factors explaining farmers' intentions to adopt BMPs (Figure 5-1). The first section (section 5.1) discusses how perceived costs may influence farmers' stated adoption intention. The cost data, derived from the economic cost study in chapter 3, were plotted against the frequency of farmers' stated intentions for each BMP. To explore how farmers' perceived costs may influence their adoption decisions, the interpretation is expressed based on graph illustration and the facts recorded during the farmers' interviews.

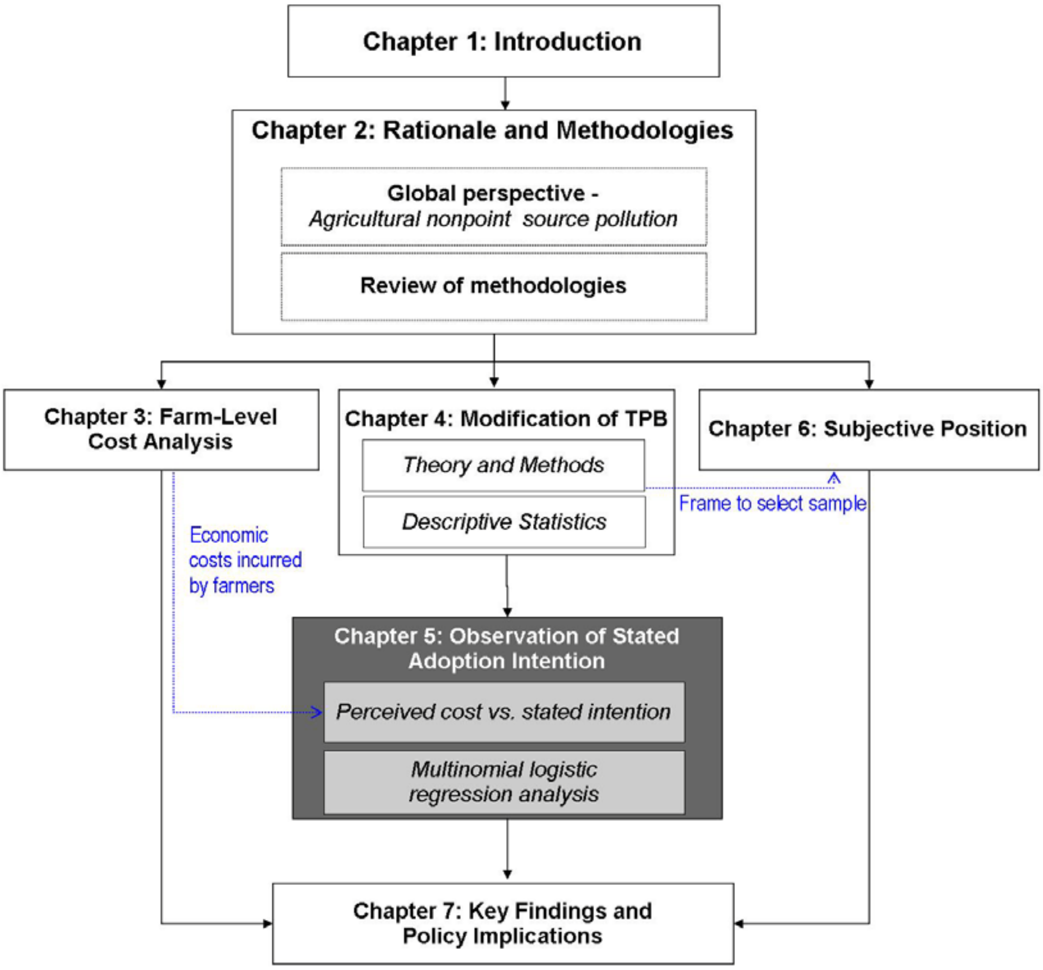

Figure 5-1: Thesis structure

Building on the previous analysis and drawing information from the descriptive statistics presented in chapter 4, the second section (section 5.2) proposes a multivariate logistic regression analysis to examine factors influencing farmers' decisions to adopt different BMPs. To perform the logistic regression, twelve BMPs are collapsed into three functional categories, which are: Good Husbandry; Vegetative Practice; and Structural Practice. Statistical diagnostic to determine independent variables and variable selection techniques are discussed. This is followed by the results from the best fit model. Section 5.3 is a discussion. This chapter is closed by a summary of main findings in section 5.4.

5.1 Perceived Costs vs. Stated Intention

In general, adoption of any environmental measure results in a number of costs to farmers and this could hinder adoption. Nonetheless, cost variables could not be included in the TPB questionnaire. Rather, during the interviews farmers were asked to self-evaluate between perceived benefits from, and perceived costs of, BMP adoption. The aim of this section is to explore how perceived cost may influence farmers' stated intentions. This section uses the economic costs data (in chapter 3) to compare with the frequency of stated intentions on adoption of each BMP (in chapter 4). It is expected that this may offer some insights into the relationships between farmers' perceived costs and their stated adoption intentions.

5.1.1 Graphical interpretation

In this thesis, farmer decision-making is assumed to be based on the perceived cost of adoption. This decision-making process is in line with Reed's (1999) argument, in that the perceived cost, rather than the absolute level of cost, is an important determinant in investment judgment. Accordingly, the costs to be discussed in this section are the farmers' perceived costs at the time the decision is made. These perceived costs include the one-time payment of the installation cost, annual maintenance cost and annual opportunity cost. In Figure 5-2 and Figure 5-3, the scatter plots present numbers of farmers selecting a particular BMP as their first option (refer to Table 4-8, chapter 4), while the bar graphs present total costs of each BMP (refer to Table 3-4, chapter 3). In general, the results show that the most popular options lie in the Good Husbandry, followed by Structural Practice and Vegetative Practice.

In Figure 5-2, the actual total costs excluding (land) opportunity costs show that Structural Practices especially practice 9 (on-site retention storage) and practice 11 (mix-load and wash-down site) are not financially attractive, but some farmers still prefer to adopt. Similarly, practice 4 (soil analysis) in the Good Husbandry is the most preferred BMP amongst farmers though it has the highest investment costs compared with other BMPs in the same category (i.e. practice 1-4).

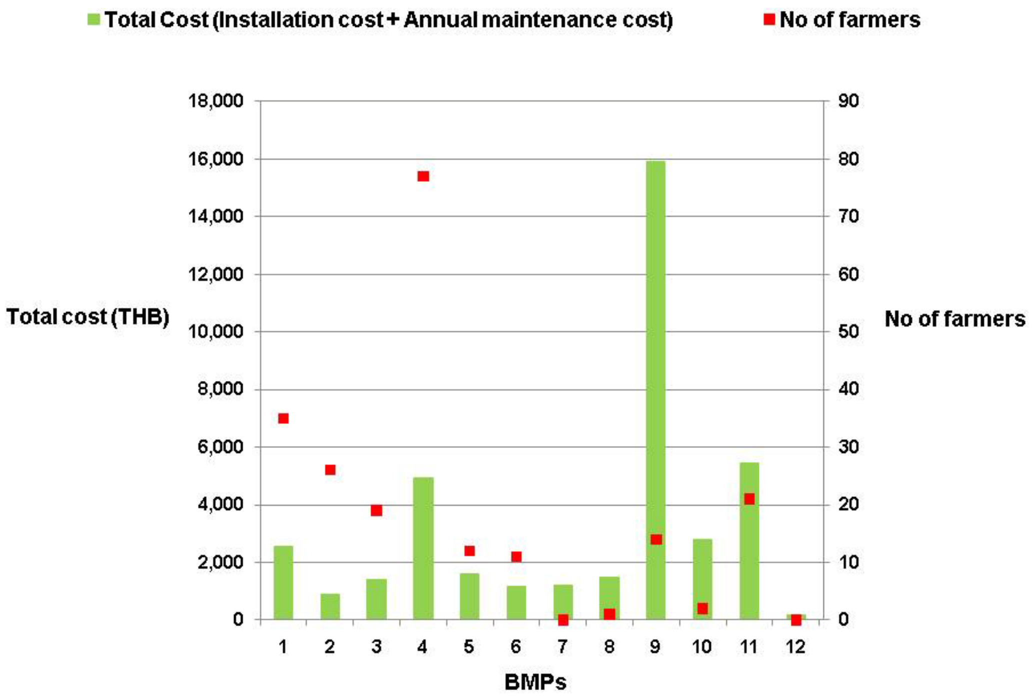

Figure 5-2: Actual installation and annual maintenance costs vs. Stated intention

Notes: The horizontal axis represents twelve BMPs. From left to right, Good Husbandry category includes practice number 1-4: 1) scheduling water structure; 2) apply herbicide within tree canopy; 3) basic restrictions for pesticide application; and 4) soil analysis. Vegetative Practice category includes practice number 5-8: 5) vegetative cover; 6) mulching; 7) vegetative buffer strip; and 8) grassed waterway. Structural Practice category includes practice number 9-12: 9) on-site retention storage; 10) terracing; 11) mix-load and wash-down site; and 12) riparian setbacks.

In Figure 5-3, the bar graph is plotted against the scatter plot to present the land opportunity cost and farmers' stated intention. Practice 7 (vegetative buffer strip) and practice 8 (grassed waterway) from Vegetative Practice, and practice 9 (on-site retention storage), practice 11 (mix-load and wash-down site) and practice 12 (riparian setbacks) from Structural Practice have relatively high actual land opportunity costs. The number of farmers who prefer to adopt these measures is relatively low, especially compared to BMPs from Good Husbandry where opportunity cost is nearer zero.

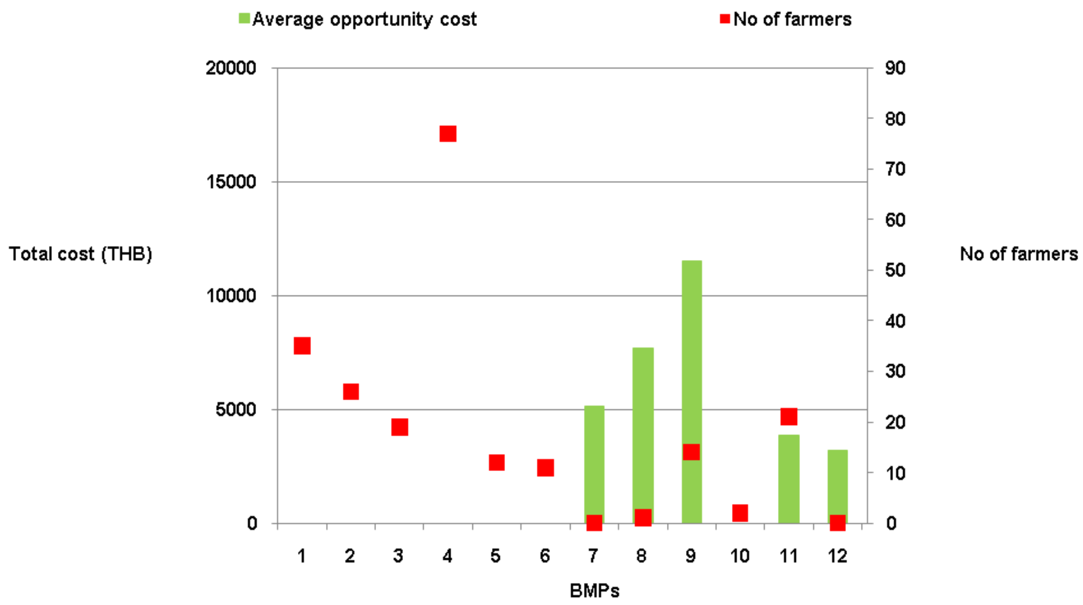

Figure 5-3: Actual land opportunity costs vs. Stated intention

Notes: The horizontal axis represents twelve BMPs. From left to right, Good Husbandry category includes practice number 1-4: 1) scheduling water structure; 2) apply herbicide within tree canopy; 3) basic restrictions for pesticide application; and 4) soil analysis. Vegetative Practice category includes practice number 5-8: 5) vegetative cover; 6) mulching; 7) vegetative buffer strip; and 8) grassed waterway. Structural Practice category includes practice number 9-12: 9) on-site retention storage; 10) terracing; 11) mix-load and wash-down site; and 12) riparian setbacks.

5.1.2 How perceived costs may affect stated intentions

In Figure 5-4 the bar graph presents the actual total costs, which include installation cost, annual maintenance cost and land opportunity cost, while the line graphs show the number of stated intentions form farmers in different locations. This graph illustrates some preliminary information important to understand the influence of perceived costs on farmers' stated intentions. The interpretation is referred back to the assumption of preference ranking mentioned in chapter 4, where farmers were assumed to make decision based on perceived costs (and perceived benefits). It was assumed that farmers consider adoption at the prices they actually face and with a consideration on characteristics of the environment in which they operate.

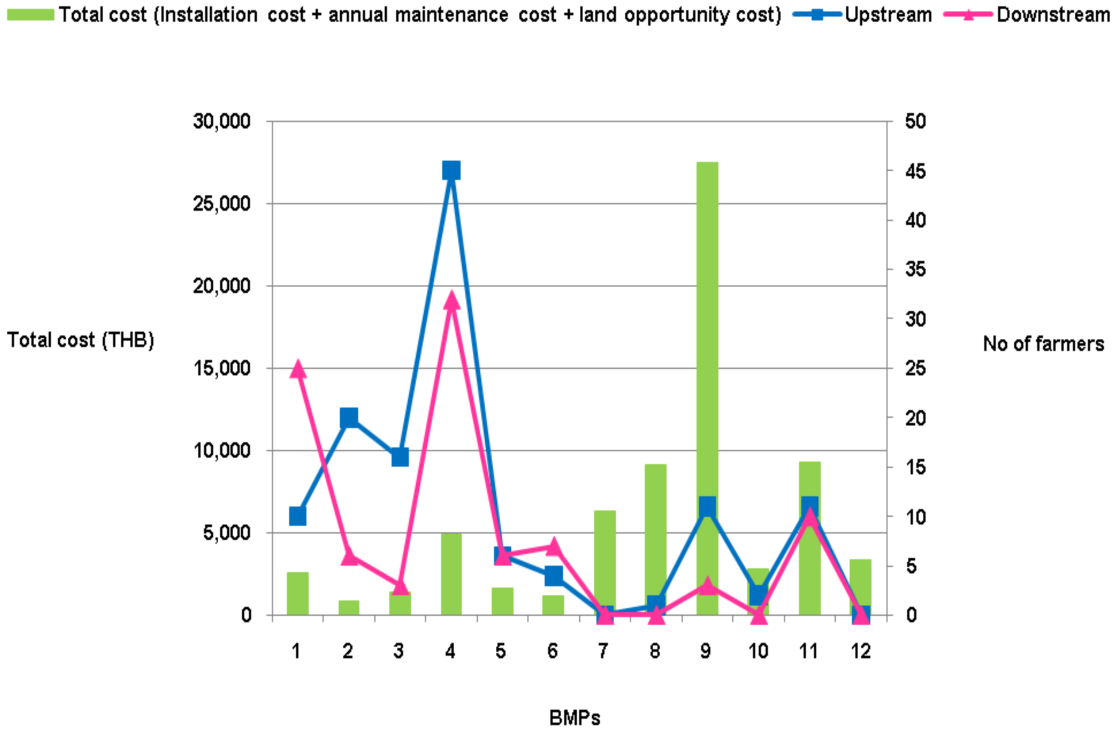

Figure 5-4: Actual total costs VS. Stated intention

Notes: The horizontal axis represents twelve BMPs. From left to right, Good Husbandry category includes practice number 1-4: 1) scheduling water structure; 2) apply herbicide within tree canopy; 3) basic restrictions for pesticide application; and 4) soil analysis. Vegetative Practice category includes practice number 5-8: 5) vegetative cover; 6) mulching; 7) vegetative buffer strip; and 8) grassed waterway. Structural Practice category includes practice number 9-12: 9) on-site retention storage; 10) terracing; 11) mix-load and wash-down site; and 12) riparian setbacks.

In general, the number of farmers preferring to adopt BMPs in Good Husbandry category (i.e. practice 1-4) is obviously higher than those preferring BMPs in Vegetative Practice and Structural Practice categories (i.e. practice 5-8, and practice 9-12, respectively). Basically, all other factors being equal, willingness to adopt BMPs decreases with a rise in cost and vice versa. This is obvious in farmers' preferences towards the adoption of Good Husbandry BMPs, which have lower investment costs in terms of both actual and perceived costs. Indeed discussions during farm interviews revealed that farmers wanted to adopt BMPs in

Vegetative Practice and Structural Practice categories, but they withdrew because they perceived a large amount of initial investment costs.

However, personal perceptions are subject to error, and the actual cost and perceived cost may differ (Ross and Stiles 1973). As illustrated in Figure 5-4, it is evident that some farmers prefer to adopt practices 9 despite the fact that the actual cost is relatively high. Further, there is no stated intention for practices 7 and 12 though the actual total cost is less than practices 8 and 9. Moreover, considered by itself the Good Husbandry category (i.e. practice 1-4), the graph illustrates that a number of farmers preferring practice 4 is the highest in spite of its highest actual cost.

At this point, the preliminary findings suggest some key points in the relationship between the stated intention and perceived costs of adoption. First, if the amount of perceived costs is obviously different and farmers can easily note this difference, farmers are likely to select the one with lower perceived cost. This is evident in farmers' preferences towards Good Husbandry category. Lui et al. (2002) explain that in the circumstance where neither net profit from BMP nor effectiveness of the practice is known, comparative cost is used to measure competitiveness among several options. The practice with the most competitive cost is likely to be adopted.

Second, when the difference in perceived costs is not definite, farmers tend to select technology that meets their own objectives, production possibilities and farm constraints. In other words, farmers weigh the advantages and disadvantages between options, and consider which BMP is the most acceptable (Franzel 1999). As BMP is a site specific practice (i.e. practicality) and its effectiveness varies across locations (Sharpley et al. 2009), farm location is taken into account in order to understand the influence of perceived costs towards the selected BMP.

Considering Figure 5-4, the graph illustrates some differences in stated intentions between farmers in upstream and downstream of the Ping river basin. For example, practice 1 (scheduling water structure) is more preferred by downstream farmers, while practice 2 (applying herbicide with tree canopy), practice 3 (basic restriction for pesticide application), practice 9 (on-site retention storage) and practice 10 (terracing) are more preferred by upstream farmers. As any BMP is site-specific, it is applicable to citrus farms if it can be installed as a retrofit of existing farm condition. Development and implementation of practice 1 is not suitable in the upstream area, where most farms are on hilly areas. Similarly, an installation of practices 9 and 10 is not applicable to farms in the downstream areas because farmers are farming in ditch irrigation systems.

On the related point, the explanation of preferences towards practice 2 and 3 is not conclusive. However, during the farm interviews, a few farmers commented on the complexity of implementation. Downstream farmers perceived that the adoption of practice 2 could impede current working conditions, and it is difficult to maintain a safe distance between the herbicide boom and the tree because of a narrow ditch. On the other hand, practice 3 was recognised as needed and worthwhile for investment as it reduces chemicals and cost. However, farmers also stated that it is time-consuming, complicated, and thus frustrating. This may in part explain why downstream farmers, holding larger average farm size, have stated lower interests in the adoption of practice 3.

In this thesis, farmers were asked to consider perceived costs and benefits from the BMP adoption. Cost perception varies across farmers, and this can influence their intentions to adopt a certain practice (Huijps et al. 2009). Farmers may value costs and benefits at the price they have experienced with, and make decision to meet their own objectives and farm constraints (Lutz et al. 1994). Even if the perceived costs of conservation practice exceed the benefits in the short run this may not discourage the adoption by some farmer groups. The findings simply indicate that although cost is regarded as an important determinant in adoption decisions, it may not be the most important factor. The findings are similar to the work of Sattler and Nagel (2010) in that factors other than cost are equally or even more important for adoption a new technology.

5.2 Multinomial Logistic Regression Analysis

The main finding from the preceding section is that cost may not be the most important factor influencing BMP adoption. This section looks beyond traditional economic theory to include aspects of social psychology. The descriptive statistics from chapter 4 provide the basis for the following analysis. This section specifically deals with the question of what are the factors influencing farmers to adopt a different type of BMP. It begins with a basic principle of logistic regression analysis for adoption models. This is followed by data screening and statistical diagnostics leading to a creation of group-specific DUMMY independent variables, and the techniques to select independent variables (i.e. added or deleted or forced-entry) in logistic regression analysis. Next, it proceeds with the use of multinomial logistic model to model the relationships between nominal-scale dependent variables and a set of independent variables. This present section is closed with the results from a multinomial regression analysis.

5.2.1 Logistic regression analysis for adoption intentions

The binary decision (i.e. adopt vs. not adopt) of citrus farmers generates a non-linear response, and thus violates the assumptions of the linear regression model (Sheikh et al. 2003). A logistic regression is more suitable to model a relationship between a dichotomous outcome variable and a set of covariates (Hosmer and Lemeshow 1989). Logistic regression analysis does not require either multivariate normality or equal variance-covariance matrices across groups. It also has the ability to incorporate nonlinear effects, and defines an S-shape relationship between the dependent and independent variables (Hair et al. 2009).

Consider a collection of k independent variables which are denoted by the vector

$$x' = (x_1, x_2, ..., x_k) \qquad \text{(Equation 4)}$$

The probability being modelled is denoted by the conditional probability statement

$$P(D = 1 | x_1, x_2, ... x_k) = P(x) \qquad \text{(Equation 5)}$$

Thus, the logistic model may be written as

$$P(x) = \frac{1}{1 + e^{-(\alpha + \Sigma \beta_i x_i)}} \qquad \text{(Equation 6)}$$

where;

α = intercept parameter

β = regression coefficient

An alternative way to write the logistic model is called the logit form. The logit is the natural logarithm of the odds of the outcome. The odds of the outcome is the probability of having the outcome divided by the probability of not having the outcome (Katz 1999). Let the logit transformation be denoted as logit P(X),

$$\text{logit } P(x) = \ln\left[\frac{P(x)}{1 - P(x)}\right] \qquad \text{(Equation 7)}$$

where $P(x)$ = equation 6

Thus,

$$\text{logit } P(x) = \ln[e^{(\alpha + \sum \beta_i x_i)}] \qquad \text{(Equation 8)}$$

$$\text{logit } P(x) = (\alpha + \sum \beta_i x_i) \qquad \text{(Equation 9)}$$

5.2.1.1 Independent variables

As from the elicitation study and literature reviews, there were thirty two independent variables included in the study. These were thirteen psychological variables and nineteen additional variables. These independent variables were subjected to see if they fit with the assumptions of multivariate model, and the statistical software used for analysing data was SPSS 16.0.

The data were first screened for normality and homogeneity of variance. The missing data were then replaced with a conditional mean substitution[15]. Statistical diagnostics revealed that: 1) only indirect measures created by a summated scale of psychological variables were reliably constructed; 2) variables with multicollinearity problems were deleted; 3) outliers and influential cases were not relevant; 4) DUMMY variables were required to solve the problem of linearity; and 5) one variable (contribution of full-time workers) contained incomplete information cells, and was excluded from the model. Thus, only thirty one independent variables were eligible for inclusion in the model. Descriptions of DUMMY variables are illustrated in Table 5-1.

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[15] For cross-sectional data, a conditional mean gives more accurate estimates of missing values. It is a mean derived from other participants in the sample who have very similar background, not a sample mean.

Table 5-1: Descriptions of DUMMY variables

Variables	Coding and Descriptions		
Socio-demographics of the farmers			
Age of farmer	AGEg1	=	≤ 30 year old*
	AGEg2	=	30.1 – 40 year old
	AGEg3	=	40.1 – 50 year old
	AGEg4	=	50.1 – 60 year old
	AGEg5	=	> 60 year old
Education level	EDUr	=	< high school*
	EDU1	=	≥ high school
Gender	GENg1	=	Male*
	GENg2	=	Otherwise
Characteristics of the farm household			
Dependence on other crops	CROPg1	=	Dependence on other crops*
	CROPg2	=	Otherwise
Past experiences in farming[16]	PASTr	=	< 15 years*
	PAST1	=	≥ 15 years
Health condition after starting citrus cultivation	HEALTHg1	=	Health problem retarding farm work*
	HEALTHg2	=	Otherwise
Structures of the farm business			
Farm size	SIZEg1	=	≤ 5 rais*
	SIZEg2	=	5.01 – 10 rais
	SIZEg3	=	10.01 – 20 rais
	SIZEg4	=	20.01 – 50 rais
	SIZEg5	=	> 50 rais
Location	UT	=	Upstream area*
	DT	=	Downstream area
Stream runs/ passes through farm	STREAMg1	=	Stream run pass/ through farm*
	STREAMg2	=	Otherwise
Soil type	SOILg1	=	Clay*
	SOILg2	=	Loam
	SOILg3	=	Sand and others
Contribution of family labours	FWr	=	Contribution of family labour ≤ 50%*
	FW1	=	Contribution of family labour > 50%
Contribution of part-time workers	PTr	=	Contribution of part-time worker ≤ 50%*
	PT1	=	Contribution of part-time worker > 50%
Contribution of full-time workers	FTr	=	Contribution of full-time worker ≤ 50%*
	FT1	=	Contribution of full-time worker > 50%
Land ownership	LANDg1	=	Own land*
	LANDg2	=	Otherwise
Household income per rai	INr	=	< median value*
	IN1	=	≥ median value
Household debt per rai	DTr	=	< median value*
	DT1	=	≥ median value
Social milieu			
Membership of agricultural association	MEMg1	=	Member of agricultural association*
	MEMg2	=	Otherwise
Access into government advisory services	nGOVg1	=	No need for services*
	nGOVg2	=	Easy or Not so difficult
	nGOVg3	=	Difficult or Not that easy
Access into other sources of advisory services	nPRIg1	=	No need for services*
	nPRIg2	=	Easy or Not so difficult
	nPRIg3	=	Difficult or Not that easy

16 Farmers' experiences could be backed up by a national policy. The 6th National Economic and Social Development Plan (1987-1991) focused on: 1) the concern over natural resource degradation; and 2) the promotion of fruit crop cultivation. The 7th National Economics and Social Development Plan (1992 – 1996) focused on the sustainable development considering a common outlook and common principles to inspire and guide the people of the country in the preservation and enhancement of human environment.

Variables	Coding and Descriptions		
Psychological factors			
Reduced production cost	ATT1g1	=	1st tercile*
	ATT1g2	=	2nd tercile
	ATT1g3	=	3rd tercile
Environmental protection	ATT2g1	=	1st tercile*
	ATT2g2	=	2nd tercile
	ATT2g3	=	3rd tercile
Gain more benefits from watershed	ATT3g1	=	1st tercile*
	ATT3g2	=	2nd tercile
	ATT3g3	=	3rd tercile
Greater commitment to farm management	ATT4g1	=	1st tercile*
	ATT4g2	=	2nd tercile
	ATT4g3	=	3rd tercile
Consumer	SN1g1	=	1st tercile*
	SN1g2	=	2nd tercile
	SN1g3	=	3rd tercile
Government	SN2g1	=	1st tercile*
	SN2g2	=	2nd tercile
	SN2g3	=	3rd tercile
Output retailer	SN3g1	=	1st tercile*
	SN3g2	=	2nd tercile
	SN3g3	=	3rd tercile
Neighbour	SN4g1	=	1st tercile*
	SN4g2	=	2nd tercile
	SN4g3	=	3rd tercile
Affordable	PBC1g1	=	1st tercile*
	PBC1g2	=	2nd tercile
	PBC1g3	=	3rd tercile
Return	PBC2g1	=	1st tercile*
	PBC2g2	=	2nd tercile
	PBC2g3	=	3rd tercile
Knowledge	PBC3g1	=	1st tercile*
	PBC3g2	=	2nd tercile
	PBC3g3	=	3rd tercile
Farm association	PBC4g1	=	1st tercile*
	PBC4g2	=	2nd tercile
	PBC4g3	=	3rd tercile
Potential market	PBC5g1	=	1st tercile*
	PBC5g2	=	2nd tercile
	PBC5g3	=	3rd tercile

Note:
(1) * reference group

5.2.1.2 Variable selection technique

In this study, external variables such as socio-demographic variables were collected from the literature, whereas psychology variables were derived from the elicitation survey. There is often a lack of theoretical literature on BMP adoption relating to psychology variables (Prokopy et al. 2008), and thus stepwise logistic regression is useful in situations where ‘important’ independent variables are poorly understood in terms of their influence on intentions (Hosmer and Lemeshow 1989). Further, the forward stepwise selection is superior to the backward method when sample size is small for the number of independent variables in the analysis (Katz 1999). Accordingly, a forward stepwise selection method was used to determine the number of independent variables to be included in the equation. After the significant psychological variables were defined, the subsequent step is to forced entry external variables into the model simultaneously.

5.2.1.3 Dependent variables

As the descriptive statistic in chapter 4 presented data based on farm locations (i.e. upstream vs. downstream areas), in this logistic regression analysis there was an attempt to assess the effects of the determinants on the outcomes by splitting cases between upstream and downstream location. However, using the statistical analysis programme (SPSS16.0), the preliminary analysis of downstream samples yielded a floating point overflow error. This error can happen when: i) the sample size is not big enough, thereby causing scattering data; or ii) the computing system does not support the specific operation on floating point numbers. As such, an alternative to analyse data is required.

Alternatively, it is worth to understand the nature of adoption based on the types of management practice, in particular when one practice may require more efforts (i.e. time, money) to implement than another (i.e. Good Husbandry vs. Structural Practices). Here, a criterion to select dependent variables is a majority rule strategy. The majority rule applies a transitivity principle implying that participants compare all possible pairs of alternatives, and decide which alternative is preferred to another (Kinoshita 1991). Suppose a farmer of size *n* is asked to choose the best among *m* potential options, there are many ways to determine a preference order for the group. With the nature of discrete rank-orderings of BMP techniques and when a complete rank-ordering is more difficult to obtain than a top choice, a majority rule can perform effectively. In other words, a potential choice is better revealed when many participants state their top choices rather than a few participants give complete rank-orderings (Wu and Annis 2007). For example, during the interviews, it is more practical to ask all participants to select and rank only the first three options, rather than ask them to rank all twelve options.

Based on the majority rule strategy, only the first ranked BMP (or the most preferred BMP) is used as a dependent variable. As there are twelve BMPs, a multinomial logistic regression is suitable for examining a relationship between nominal-scale dependent variables and multiple independent variables. To do this, twelve BMPs were collapsed into three functional categories (refer to Table 1-5) in order to create three dependent variables: Good Husbandry; Vegetative Practice; and Structural Practice. These three categories are not mutually exclusive, but the probability of farmers experiencing any single outcome is between zero to one.

5.2.1.4 Multinomial logistic regression

Multinomial logistic regression enables a calculation of the proportion that farmers fall into one outcome category relative to the other two (Unrau 1998). It is applied to determine the combination of independent variables that most influence the probability of a farmer selecting one of the three functional categories. Multinomial logistic regression requires a reference group to generate a regression model for nominal dependent variables. Reference group is the category omitted in the analysis and the odds ratio is to be compared with this reference group (Katz 1999).

In this study, there are two reasons why Good Husbandry is selected as a reference group. First, Good Husbandry is the largest group. Katz (1999) explained that if the logistic model has the largest group as the reference group, the standard errors are smaller and the confidence intervals are narrower; thereby increasing more precise estimates. Second, Good Husbandry provides baseline information that may be useful to compare with Vegetative and Structural Practices in terms of financial and technical requirements to facilitate the BMP implementations. For example, the interpretation could demonstrate the variables influencing intention to adopt practices with higher up-front investment (i.e. those within Structural Practice).

The analysis is expressed as an (log) odds ratio. Odds is the ratio of the probability that event occurs to the probability that it does not, and the odds ratio is used to compare the odds of those two groups by dividing the odds in group one by the odds in group two (Westergren et al. 2001). An interpretation of the odds ratio is superior to other indicators in that it provides an estimate with confidence level for the relationship between two binary variables, and the ratio remains the same no matter how data arrangement in a table is switched (Bland and Altman 2000).

The odds ratio given in SPSS 16.0 is labelled ‘Exp (B)’. The odds ratio greater than 1 means that an independent variable increases the logit and increases odds of event occurs. The odds ratio less than 1 means that an independent variable decreases the logit and decreases odds of event occurs. The odds ratio equal to 1 means that an independent variable has no effect. An interpretation of odds ratio for any particular independent variables is explained when all other independent variables in the model are held constant.

To do the analysis, the forward stepwise method was first used to select psychological variables. Results of the step summary are presented in Table 5-2 (for more details, see Annex 7).

Table 5-2: Summary of forward stepwise procedure

Step	Action	Effect(s)	Model fitting criteria			Effect selection tests		
			AIC	BIC	-2LL	Chi-square	df	Sig.
0	Entered	Intercept	340.065	346.834	336.065			
1	Entered	PBC1g3	335.615	349.153	327.615	8.451	2	.015
2	Entered	PBC2g2	330.383	350.690	318.383	9.232	2	.010
3	Entered	SN1g2	327.587	354.662	311.587	6.769	2	.033
4	Entered	SN1g3	321.767	355.612	301.767	9.820	2	.007
5	Removed	PBC1g3	322.111	349.187	306.111	4.344	2	.114

For this model, PBC1g3 (perception that affordability highly influences BMP adoption) entered first in the stepwise procedure, followed by PBC2g2 (perception that the return is neither important nor unimportant in BMP adoption), SN1g2 (perception that the consumer is neither important nor unimportant in my decision to adopt BMPs), and SN1g3 (perception that the consumer is very important in my decision to adopt BMPs). However, PBC1g3 was removed from the model in the final step. It is likely that PBC1g3 may relate to other independent variables, and thus the Variance Inflation Factor test (VIF) was used to scan for any multicollinearity. The analysis revealed that no VIF value was greater than 10, thus indicating no serious multicollinearity effect (Field 2005).

Table 5-3 presents the psychology variables selected by the forward stepwise method. Three psychology variables remaining for the analysis are SN1g2, SN1g3, and PBC2g2.

Table 5-3: Final model selected by forward stepwise method

Category of the adoption choice[a]		**B**	**Std. error**	**Exp(B)**	**95% CI for Exp(B)**	
					Lower	**Upper**
Vegetative Practice	Intercept	.252	1.163			
	SN1g2	-2.106	1.091	.122	.014	1.033
	SN1g3	-2.700*	1.052	.067	.009	.528
	PBC2g2	.899	.488	2.457	.945	.6388
Structural Practice	Intercept	-3.435*	.719			
	SN1g2	1.394*	.592	4.031	1.263	12.862
	SN1g3	.372	.408	1.451	.652	3.230
	PBC2g2	.975*	.422	2.652	1.161	6.060

Notes: (1) [a]The reference category is: Good Husbandry
(2) R^2 = 0.13 (Cox & Snell), 0.16 (Nagelkerke), 0.09 (McFadden)
(3) *significant at the 0.05 level
(4) n = 218 observations ($n_{\text{Good Husbandry}}$ = 157, $n_{\text{Vegetative Practice}}$ = 24, $n_{\text{Structural Practice}}$ = 37)

The next step is to enter these three psychology and external variables into the equation. The combined model, of only the final regression results, is presented in Table 5-4 (for more details, see Annex 8). This combined model is significant at .05 level and the R^2 of Cox & Snell, Nagelkerke, and McFadden is 0.43, 0.55, and 0.36, respectively.

Table 5-4: Combined model with psychological variables and external variables

Category of the adoption choice[a]		**B**	**Std. error**	**Exp(B)**	**95% CI for Exp(B)**	
					Lower	**Upper**
Vegetative Practice	Intercept	-23.172*	7.831			
	SN1g2	-2.774*	1.271	.062	.005	.753
	SN1g3	-3.625*	1.239	.027	.002	.302
	PBC2g2	1.651*	.731	5.214	1.246	21.827
	SIZEg2	1.998*	.995	7.373	1.048	51.874
	FW1	2.854*	1.421	17.363	1.071	281.476
	nPRIg2	2.301*	1.005	9.980	1.391	71.605
Structural Practice	Intercept	-1.666	5.548			
	SN1g2	2.277*	.782	9.752	2.104	45.190
	PBC2g2	1.318*	.584	3.736	1.190	11.724
	CROPg2	2.308*	.789	10.056	2.142	47.223
	SIZEg4	-2.451*	.942	.086	.014	.546
	SIZEg5	-4.108*	1.164	.016	.002	.161

Notes: (1) [a]The reference category is: Good Husbandry
(2) R^2 = 0.43 (Cox & Snell), 0.55 (Nagelkerke), 0.36(McFadden)
(3) *significant at the 0.05 level
(4) n = 218 observations ($n_{\text{Good Husbandry}}$ = 157, $n_{\text{Vegetative Practice}}$ = 24, $n_{\text{Structural Practice}}$ = 37)

The logistic regression models can be written as follows:

$$\text{Logit (VP)} = -23.17 + (-2.77)\ \text{SN1g2} + (-3.63)\ \text{SN1g3} + (1.65)\ \text{PBC2g2} + (1.99)\ \text{SIZEg2} + (2.85)\ \text{FW1} + (2.30)\ \text{nPRIg2} \quad \text{(Equation 10)}$$

$$\text{Logit (SP)} = -1.67 + (2.28)\ \text{SN1g2} + (1.32)\ \text{PBC2g2} + (2.31)\ \text{CROPg2} + (-2.45)\ \text{SIZEg4} + (-4.11)\ \text{SIZEg5} \quad \text{(Equation 11)}$$

Equation 10 represents the log of probability to adopt Vegetative Practice over Good Husbandry. When all variables were entered into the equation the three psychology variables remained significant. Holding all other variables constant, results show that farmers who are indifferent to (SN1g2) or those who highly care about consumers (SN1g3) have 0.06 (= $e^{-2.774}$, Table 5-4) and 0.03 times lesser odds of adopting Vegetative Practice than those who are less concerned about consumers. Furthermore, farmers who hold indifferent preference towards perceived farm returns (PBC2g2) have 5.21 times greater odds of adopting Vegetative Practice than those who hold negative or positive preference towards perceived farm returns. Further, farmers with the farm size of 5.01-10 rais (SIZEg2) have 7.373 times greater odds of adopting Vegetative Practices than other farmer groups. Citrus farms depending on more than 50% of family labour (FW1) have 17.36 times greater odds of adopting Vegetative Practices than farms with less than 50% contribution of family labour. Lastly, farmers who have easy/ not so difficult access to information sources other than government agents (nPRIg2) have 9.98 times greater odds of experiencing Vegetative Practices than those who are faced with difficult/ not so easy access.

Equation 11 represents the probability of adopting Structural Practice over Good Husbandry. When all variables were entered into the equation, only two psychology variables remained significant. Holding all other variables constant, results show that farmers who hold indifferent preference towards consumers (SN1g2) have 9.75 times greater odds of adopting Structural Practice than those who hold a negative or a positive preference. Further, farmers who hold an indifferent preference towards perceived farm returns (PBC2g2) have 3.74 times greater odds of adopting Structural Practice than farmers who hold a negative or a positive preference towards perceived farm returns. Moreover, a few more external variables are significant. Farmers who depend solely on citrus cultivation (CROPg2) have 10.06 times greater odds of adopting Structural Practice than farmers with farm diversification. Farmers who occupy farm land of 20.01-50 rais (SIZEg4) decrease the odds of adopting structural practice in their farm by 0.09 times, and those who occupy farm land more than 50 rais (SIZEg5) decrease the odds of adopting structural practice in their farm by 0.02 times.

5.3 Discussion

There has been much discussion about which factors determine the intention to adopt new conservation practices. This study draws a conclusion that both psychological and external variables contribute to BMP adoption. The summaries of the causal relationship between stated adoption intention and significant determinants are described as follows.

5.3.1 Influence of perceived cost on stated adoption intentions

The analysis in the first section attempted to investigate the relationship between perceived costs and farmers' stated intentions. Because of the difference in the underlying assumptions between traditional economics and psychology, objective cost could not been included in the TPB model. Rather, an investigation was done on the assumption that farmers made decisions upon perceived costs, rather than actual costs. The graph presenting the actual total costs of BMP against the numbers of farmers selecting such BMP as their first option. The interpretation based on the graph layout and results from farmers' interviews has led to the conclusion that there is no definite trend in the relationship between perceived costs and stated intentions.

The importace of perceived costs on adoption decision could be explained by the stepwise method to select psychological variables. The TPB works by allowing participants to evaluate the belief-statements and indicate whether they agree or disagree with such statements. Attention should be paid to the two perceived behavioural control variables, affordability for BMP implementation (PBC1) and perceived returns from the BMP adoption (PBC2). Based on the TPB, these two factors were derived from the elicitation study, thereby indicating that both vairables are important. However, the statistical analysis showed that the PBC1 did not provide a significant contribution to the model. Overall, the investigations into perceived costs and stated intentions show that perceived cost varies across farmers and could affect adoption intentions for a certain BMP. Farmers do not always select an option with the lowest cost because they also consider other factors when making decisions.

5.3.2 Influences of psychological determinants on stated adoption intentions

5.3.2.1 Subjective norm: consumer referents

The empirical analyses reveal that farmers who are indifferent towards consumer referents or those who are highly influenced by consumers are unlikely to adopt Vegetative Practice, while those who are indifferent towards consumers tend to adopt Structural Practice. The direction of relationship between attitudes towards consumer referents and BMP adoption is not definite; rather it depends on the consumer's preference and the specific characteristics of BMPs.

The farmer's perception of consumer preference could play a role in the adoption decision (Guehlstorf 2008; Kaine and Bewsell 2008). In response to market signals sometimes farmers have to adopt new technologies even if they have not been able to skill on them (Stone 2007). On the other hand, farmers who want to adopt an eco-friendly production process are faced with consumers' existing demand for conventionally produced food. This is because the adoption of safer production is critical for a drop in the external appearance of fruit such as colour, size and shape, and it is these attributes that are most used to evaluate the quality of fruit when a consumer makes the buying decision (Sule Alonso et al. 2002). In Thailand, consumers typically buy fresh fruit with a good physical appearance (Oates 2006). Considering only the effect of consumer preference on their decisions, farmers will always supply what the consumers want (Poole and Baron 1996; East 1993). Because BMP adoption could reduce the external quality of fruit, it is possible that farmers who are influenced by consumers are unlikely to adopt the practices.

Although consumers' preferences are important for investment decisions, another concern emerged during farmers' interviews. Farmers stated that while making decisions, they also considered the potential benefits from technology adoption. Tangible benefits from adopting Structural Practice are more prevalent and observable than Vegetative Practice. For example, a retention pond can store water during a dry season, or a loading station can provide equipment storage and reduce health risk. At this point, the results suggest that the adoption decision of a certain BMP is associated with farmers' attitudes to consumers' values weighed by expected gains from the adoption of such practice. Farmers who are indifferent towards consumers are likely to adopt Structural Practice rather than Vegetative Practice, and farmers who are highly influenced by consumers are unlikely to adopt Vegetative Practice.

5.3.2.2 Perceived behavioural control: perceived farm return

Farmers differ in the degree to which they accept risk. Farmers' attitudes can be divided into three categories that are risk taker, risk neutral and risk averse (FAO 2007a). Risk-related attitudes are an important factor in investment planning and can result in different responses to adoption of new technology (Setia and Johnson 1988). The empirical analyses show that farmers who are indifferent towards a perceived farm return are likely to adopt Vegetative and Structural Practices.

Many studies found that a primary reason for adoption of conservation practices was a farmer's perception about perceived benefits (Rolfe et al. 2008; Gillespie et al. 2007; Valentin et al. 2004; Cary et al. 2001; Cary and Wilkinson 1997). There is a possibility that farmers who hold more positive perceptions about the outcomes of conservation practices are more likely to adopt new innovations (Bosch and Pease 2000). Furthermore, risk neutral farmers are less sensitive to changes in net farm return than risk averse farmers (Fafchamps 2003; Setia and Johnson 1988). As the potential outcomes of adopting a new practice are hardly predictable (Pannell et al. 2000), it is likely that farmers holding indifferent preferences towards farm returns may adopt BMPs.

5.3.3 Influences of external determinants on adoption intentions

5.3.3.1 Contribution of family labour to farm workload

It is hypothesised in this study that the contribution of family labour to farm activity is positively associated with BMP adoption. The findings reveal that farms relying on more than 50% of family labour in farm workload are likely to adopt Vegetative Practice. The Vegetative Practice demands much management time and labour, and family members could provide unpaid farm labour to the enterprise. Thus, a farm that relies mainly on family members is likely to adopt labour-intensive practices. The empirical findings are generally consistent with Gillespie et al. (2007) and Fernandez-Cornejo et al. (1994) in that family labour supply is positively associated with the adoption of labour-intensive practices.

5.3.3.2 Farm size

This study assumed that farm size has a significant effect on technology adoption behaviour in the agricultural sector, but it did not assign the direction of relationship. Literature showed that farm size had different effects on the adoption rate depending on the characteristics of BMPs. Many studies found that larger sized farms have generally been associated with an increased likelihood to adopt technology. This is because smaller farmers tend to be faced with large fixed costs, transaction costs and information costs; thereby reducing the tendency to adopt new innovation (Larson et al. 2007; Zubair and Garforth 2006; Beedell and Rehman 2000; Fernandez-Cornejo et al. 1994; Earle et al. 1979). However, a few studies revealed that smaller farmers adapted faster to new technology and perceived less problems than large-scale farmers (Feder et al. 1985; Greene 1973).

The empirical analyses reveal that small-scale farmers holding farm land of 5.01-10 rais are likely to adopt Vegetative Practice. There are at least three factors explaining adoption of Vegetative Practice by small farms. These factors are trialability, compatibility and complexity, and they are termed as programme factors[17] by Rolfe et al. (2008). First, Vegetative Practice offered in this study can be applied on a small scale (i.e. the most selected practices are vegetative cover and mulching). Thus, farmers are able to trial prior to full implementation. Second, the selected Vegetative Practice might be compatible with existing farming methods and cropping system. Third, the innovation is not complex and materials such as straw, grass, and vetiver can be found locally with relatively cheap cost.

On the contrary, the empirical analyses reveal that farmers who hold farm land of either 20.01-50 rais or more than 50 rais are unlikely to adopt Structural Practice. The negative sign between Structural Practice adoption and farm size can be described by the characteristics of BMPs. In Thailand, for small- to medium- scale farmers land area of more than 20 rais is considerably large. Structural Practice typically requires high initial investment and the following maintenance costs. Moreover, farmers incur land opportunity cost because the BMP instalment reduces the production area for farming and causes net production cost

[17] Programme factors are characteristics of a programme that could influence participation rate. There are complexity, congruence, risk and uncertainty, capital implementation cost, intellectual implementation cost, flexibility, financial incentives, duration and continuity of the programme, and institution.

(Rolfe et al. 2008; Thurston 2006; Hoppe and Wiebe 2002; Stanley 2000; Woznick 1987). Farmers are likely to adopt a new innovation, if such innovation can provide a reasonable financial viability for the business (Pannell et al. 2006). However, farmers often tend to overestimate privately short-run loss and overlook important medium- and long-term benefits especially those associated to society (Stanley 2000) since it is difficult to quantify and value social benefits. Because the current perceived economic costs outweigh economic benefits, farmers therefore do not prefer the adoption of Structural Practice.

5.3.3.3 Access to information sources other than government

Besides information from government agents, farmers also rely on information from a network of providers such as chemical dealers, input supply retailers and community leaders. Farmers are likely to adopt new innovation, if technical assistance can be easily received from this network (Gillespie et al. 2007; Feather and Cooper 1995; Traore et al. 1998). This study hypothesised that easy accessibility to information sources is positively associated with BMP adoption. The results show that farmers who have easy or not so difficult access to non-government extension services are likely to adopt Vegetative Practice.

These findings are consistent with arguments by Pannell et al. (2006). They describe farmers' tendency to adopt conservation practices, if they can seek technical assistances from people who are seen to be experts. During the survey, farmers stated that a non-government extension service is credible and the support of innovation is clearly suitable to local circumstances. Further, a great number of private extension agents are available at local level. This could enhance adoption rate because farmers receive high exposure to the information (Pannell et al. 2006). Another reason why access to private extension service is positively associated with adoption intention is the history of relationship between farmers and agents. In the past few years the major role of government extension agents in Thailand is to promote farming practices to provide public goods such as environmentally friendly production, rather than to support farmers to achieve their personal goal such as financial viability. This has created a complex social interaction that may be less comfortable for farmers and government agents; as such this enhances the role of private extension agents.

5.3.3.4 Crop dependency

Dependence on other crops indicates the number of activities other than citrus cultivation run in the farm, and simply signifies farm diversification. It is hypothesised that more diversified farms are more likely to adopt conservation practices because such adoption can potentially benefit other farm business sections (Gillespie et al. 2007; Fernandez-Cornejo et al. 1994). Moreover, a variety of practices can be trialled in a diversified farm, thereby making it more likely to adopt new innovations (Rahelizatovo and Gillespie 2004).

Contrary to the hypothesis, farmers who depend only on citrus cultivation are likely to adopt Structural Practice. Zentner et al. (2002) stated that managers of diversified farms demand more time on management, such as monitoring and obtaining marketing. Further, with more crop varieties farmers go through a learning process which could increase risks. For example, production costs might increase because of misjudgement or until new experiences is mastered. Moreover, Prokopy et al. (2008) describe that farm diversity may have a negative sign with conservation practice adoption because farmers face with too many choices and are unable to make decision within limited time and information.

5.4 Summary

Cost estimates in chapter 3 and descriptive statisics in chapter 4 provide ground information for the analysis in this chapter. The analysis in the first section aims to explore how farmers' perceived costs can affect their adoption intentions. To do this, actual cost data were plotted against the frequency of stated intentions. The graph showed no definite trend in the relationship between actual costs and stated intention. However, the further discussion based on the graphical illustration and farmer interviews has led to the conclusion that cost is crucial in farmers' decision-making, but it may not be the most important determinant. This is because farmers may make decisions based on other farm's goals, such as environmental stewardship.

This chapter then proceeds to examine factors affecting the decision to adopt different BMP types. The twelve BMPs were collapsed into three functional categories: Good Husbandry; Vegetative Practice; and Structural Practice. Farmers' decisions to adopt a specific functional BMP category were investigated through a two step multinomial logistic analysis.

First, statistical assumptions underpinning logistic regression analysis were validated, and thirty one independent variables were retained. Then, the forward selection method was conducted to select psychological variables. During the stepwise analysis, four psychology variables were entered into the equation, but one variable (i.e. affordability) was removed in the final step. Therefore, only three psychology variables were kept for the next step. Next, a combined model comprising of those three psychology variables and external variables were entered into the equation at .05 level of significance.

Results from the multinomial logistic analysis show that farmers who are indifferent to or highly influenced by consumers are unlikely to adopt Vegetative Practice. Further, farmers who hold indifferent preferences towards perceived returns are likely to adopt Vegetative Practice. Farmers who occupy the farm land of 5.01-10 rais, or a farm having a high contribution of family labour to farm workload, or farmers who easily receive information apart from government advisory services are likely to adopt Vegetative Practices. In terms of the determinants of Structural Practice adoption, at the .05 level, farmers who are indifferent towards consumer referent are likely to adopt Structural Practices. Further, farmers who hold indifferent preferences towards perceived returns are likely to adopt Structural Practice. Farmers who depend only on citrus production are likely to adopt Structural Practice. However, farmers with large farm size are unlikely to adopt Structural Practice.

Overall, this study begins to examine in which way perceived cost can affect farmers' stated intention. It then draws on the TPB and econometric estimation model as a framework for understanding decisions to engage in BMP uptake at a landscape level. The TPB combines both qualitative and quantitative methods. It requires qualitative research in the elicitation study of attitudes, subjective norms, and perceived behavioural controls; while the statistical analysis developed to use with the TPB is quantitative in nature. Moreover, in the context of agri-environmental policy where other factors may be more important than beliefs and attitudes in determining behaviours, external variables can be added into the model. The results suggest that participation varies across different types of BMP. Further, the significant factors derived from the statistical analysis are useful for policymaking. These factors could provide a frame for minimum eligibility requirements for farmers and technical standards for farms to participate in a BMP programme. To design a more targeted policy approach accommodating differences between farmers, the next chapter introduces Q-Methodology.

6 SUBJECTIVE POSITION

This chapter is an extension of the previous chapter, which observes farmers' adoption intentions (Figure 6-1). Though behaviour can be predicted by personal intention, intentions do not always lead to the final behaviour because people may not behave in line with their intentions. Furthermore, salient beliefs may differ from individual to individual and from population to population, and this proposition has not been addressed within the TPB framework (Cook et al. 2005). Provided there is another procedure for assessing the subjective importance of beliefs, this could improve an understanding underlying a decision process of specific subgroups and could offer tailored policy interventions.

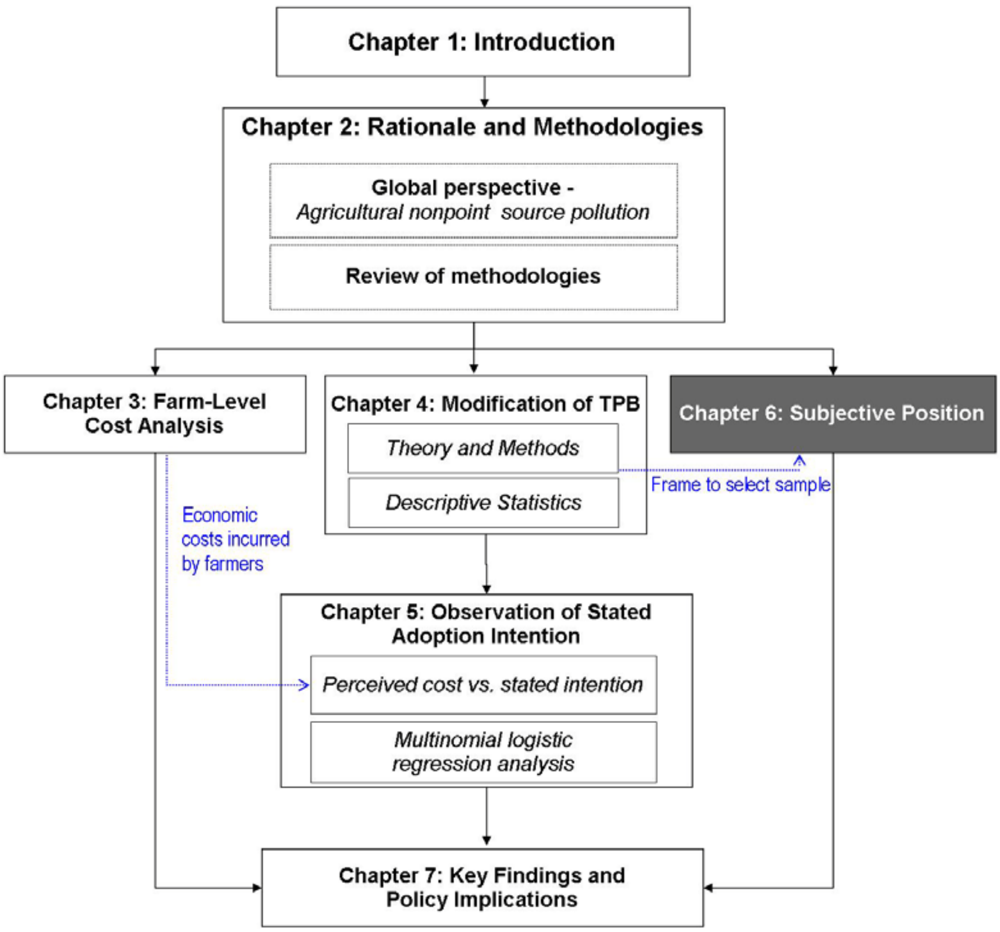

Figure 6-1: Thesis structure

This chapter begins with a discussion about current statistical techniques to segment people based on their attitudes (section 6.1). Section 6.2 presents a development of concourse and a strategy to select statements within the Q-Methodology. This section also provides the criteria to select small-scale participants from a pool of TPB samples. In section 6.3, a field survey and fieldwork tools are detailed. The justification of data analysis is further presented in section 6.4, and followed by results based on citrus farmer’s subjectivity in section 6.5. The discussion in section 6.6 points to cautions in the application of Q-Methodology. This chapter closes with the summary in section 6.7.

6.1 Attitudinal segmentation

Practically, cluster analysis and Q-Methodology are widely applied to investigate attitudinal similarities and differences between groups (Morf et al. 1976). Cluster analysis is a statistical technique used to identify groups with heterogeneous inter-group and homogeneous intra-group characteristics (Aldrich et al. 2007). In other words, it is a technique to segment individuals into categories so that the individuals in the same category are more statistically similar to each other than those who are in other categories. For example, attitudes were measured by a series of statements presenting in the forms of Likert-scales ranging from ‘strongly agree’ to ‘strongly disagree’ (Gorton et al. 2008).

Several studies employed cluster analysis to investigate farmers’ attitudes to agri-environment policy. For example, Lobley and Butler (2010) performed a cluster analysis with 1,852 farmers in Southwest England to investigate their reaction to CAP reform. The analysis yielded five distinct groups, and suggested that different farming situations (i.e. farm structures) are associated with different types of reaction (i.e. slightly influenced by CAP reform). Vanhonacker et al. (2007) conducted a cluster analysis with 459 meat consumers to understand their attitudes towards farm animal welfare. The results revealed six groups and also suggested information regarding markting opportunities for high welfare products.

Gorton et al. (2008) conducted a cluster analysis with 1,192 farmers from five EU countries in order to investigate differences in attitudes towards agricultural policy amongst the EU Member States. The five-cluster solution was obtained. Each group is first described based on its attitudinal perspectives, and it is then refined based on its demographic and farm structure variables. Kuehne et al. (2008) performed a cluster analysis with 121 irrigators to investigate attitudes influencing willingness to participate in a water reform. Three-cluster solution was chosen as it has a strong conceptual support, and as such each cluster is meaningful. Garforth (2010) conducted a cluster analysis with 683 farmers to investigate whether farmers with different sets of attitudes respond differently to the introduction of the Single Payment scheme. The results showed that profit maximisation is not important for all farmers.

Q-Methodology, on the other hand, is an agency- or person-centred approach, which provides insight into the structure of attitudes and indicates which aspect of behaviour is important. Barry and Proops (2000) classify Q-Methodology as attitudinal research along with as semi-structured interview and focus groups, but offers stronger qualitative methods providing a distinctive approach to empirical analysis. Recently, Q-Methodology is used to understand farming style in the context of a rapidly changing agri-environmental policy (Davies and Hodge 2007). The concept of farming style is that, in any farming community, there is a set of farming strategy of which farmers are aware and from which they choose to guide their own practice (Vanclay et al. 2006). Accordingly, understanding what are underlying these basic motivations and how farmer perceives a new practice can help to design policy that may receive positive responses. Examples of study employing Q-Methodology to investigate farmers' responses to new practices are given as follows.

Hall (2008) studied farmers' attitudes to GM crops in Scotland using Q-Methodology. She argued that previous studies usually focused on attitudes of consumers and agency bodies, such as industry and NGOs, and not much attention was paid to farmers. The study, thus, aimed to add farmers' views to the overall GM debate. The findings suggested that farmer is a unique stakeholder group in the GM debate in that it is neither extremely pro- nor anti-GM. Rather, farmers prefer to wait and see the consequences of GM cultivation (i.e. benefits of the technology) from other stakeholders (i.e. biotechnology companies).

Brodt et al. (2006) conducted the Q study and found three groups of farmer holding unique combinations of goals and values that result in different farm management strategies. This simply suggested that farmers may not adopt new practice if its values are not consistent with their personal values. Moreover, diversities of farming style were then used to inform policy to promote alternative farming practices. Davies and Hodge (2007) used the Q-Methodology to explore environmental perspectives of East Anglian farmers. Five groups were revealed and different policy orientations were suggested to correspond with different groups.

Fairweather and Klonsky (2009) discussed the usefulness of Q-Methodology in terms of the extension to policy implications. They concluded that Q-Methodology is a suitable method for documenting farming styles and this knowledge allows an effective policy intervention targeting at salient motivations or attitudes. Stewardship positions revealed by the Q studies suggest that farmers' core values and motivations are not only influenced by profit maximisation. To a degree, this is align with the hypothesis underlying in Ecological Economics that farmer is unbounded rational.

Overall, cluster analysis offers two clear advantages. First, it can pinpoint the differences between each group based on attitudes and other variables such as demographic and geographic characteristics (ten Klooster et al. 2008), thus improving the profiling and validation of each cluster. Second, it is a preferred method when groups are identified based on a large number of variables (Aldrich et al. 2007). However, as criticised by Hair et al. (2009) cluster analylsis also has some limitations. First, the sample size must be large enough to provide sufficient representation of small groups within the population and to represent the underlying structure. Second, the cluster solution could not be generalised since it depends on the variables used as the basis for the similarity measure. Third, the variables used in the analysis must have a strong conceptual support because they will form the interpretation of a corresponding cluster.

Several advantages of Q-Methodology are prior highlighted in chapter two (see 2.2.2). However, as a research methodology, Q study also has some limitations. First, the sorting process is time-consuming (McKeown and Thomas 1988). For example, method and instructions must be clearly explained to participants. Second, as paticipants in the Q study are purposively selected, the generalisation of the results could not be made (Danielson 2009). Third, participants are segmented based on their attitudes toward studied subject. The interpretation based on other variables, such as demographic variables, is not recommended because of the small sample size of participants (Danielson 2009).

Cluster analysis and Q-Methodology have different strengths and weaknesses. Morf et al. (1976) argued that Q-Methodology is a more promising method to classify groups than is cluster anlaysis. In terms of mathematical basis factor analysis, an underlying method in the Q analysis, provides less susceptible to sampling fluctuations. This is because it takes into account the entire matrix of similarity indices between observations in forming groups. In other words, the broad dimensional Q factor analysis allows for the possibility that participants are moderately associated with a number of variables, while the categorical cluster analysis assumes that participants are maximally associated with one category and not with all others.

Apart from the discussion above, the desired method for capturing attitudinal heterogeneity may depend on research goals and data availability. The Q-Methodology presents itself as an attitudinal study that could support the extension of the TPB and can be implied for the formulation and analysis of an agri-environmental policy (Barnes et al. 2007). Q-Methodology aims to understand spectrum of views by using the process that is relatively independent of the researcher (Fairweather and Klonsky 2009). Accordingly, this chapter offers an application of Q-Methodology in order to understand how attitudes impact on the achievement of goal (i.e. BMP adoption).

6.2 Concourse Development and Establishing the Q-sample

The flow of information surrounding any topic in a Q application is termed a ‘concourse’. It is from this concourse that a sample of statements is subsequently drawn for administration in a sorting process (Brown 1991). In this study, the concourse relating to BMP adoption was collected from document review and personal interviews based on a set of thirteen open-ended questions[18]. Example questions are: ‘what do you believe are the advantages/

[18] This was the same questionnaire used during the TPB elicitation study (see Annex 5), and the interviewed farmers were the same. In other words, the interview records from the same sources (i.e. questions and interviewees) were used as inputs for both the TPB and Q study. However, different approaches were used to derive variables/ statements for the analysis. In the TPB study, variables were derived by the content analysis (see 4.1.3.2) while in the Q study statements were categorised by relevant issues (Table 6-1).

disadvantages of BMP uptake?', and 'are there any conservation practices done on your farm and what are they?'. Seventeen citrus farmers were interviewed in June 2007. They were firstly informed about possible effects of citrus production on water quality and briefly introduced to twelve BMPs selected by Thai agronomists as being those most relevant to citrus farming in the study area (Table 1-5, Chapter 1). The concourse was subsequently broken down into 419 statements. These statements represented 91 statements from printed materials and 328 statements from the personal interviews.

Next, a subset of statements must be drawn from the concourse. van Exel and de Graaf (2005) argued that these statements can be selected based on either existing theory or induction from a survey feedback. They further discussed that either selection approches could lead to a logical contruct of Q-sample as it is the participants who eventually give a meaning to these statements through a sorting process. In this study, to ensure that the Q-samples represented the entire concourse, a strategic sampling was applied. A matrix was used to categorise 419 statements (Table 6-1).

Table 6-1: A two-dimensional matrix for statement categorisation

Statement topic	Social	Ecological	Economic
Water resource management	(2)	(2)	(2)
Soil conservation	(2)	(2)	(2)
Pest control	(2)	(2)	(2)
Fertiliser use	(2)	(2)	(2)
Overall views	(4)	(4)	(4)

Note: The number in parentheses represents total statements chosen from each corresponding cell and thus yields a total set of 36 statements for the analysis.

The thematic categories on the horizontal axis were based on the concept of sustainable agriculture, and were social, ecological and economic aspects, while those on the vertical axis were based on the technical aspects of BMPs, and were water resource management, soil conservation, pest control, fertiliser use and overall views towards BMP adoption. From 419 statements, there are a few criteria to decide which statements will be selected as Q-samples. First, the statements should be short, stand-alone sentences that are easy to understand. Second, the statements should accurately represent 'what is said' in the concourse (Webler et al. 2009). Third, the Q-sample should include statements that provide the fullest range of viewpoints in the concourse (Durning and Brown 2006). The matrix not only allows a categorisation of statement, but also offers a stratified random sampling for statements selected from each cell. Using this matrix, a total of 36 statements for the Q-sample was derived for the analysis (Annex 9).

6.3 Administering the Q-sort

The statement sorting (ranking) exercise was undertaken in December 2007 and August 2008. Theoretically, the number of participants does not have to be large to ensure the comprehensiveness of factors and the reliability of the factor arrays (Brown 1980: 92). In this study, 72 out of 218 TPB participants were purposively selected for the Q analysis. The selection criteria are based on farm size, education level and age, to represent farmers from different areas in the Ping river basin (51% were upstream farmers and 49% were downstream farmers).

During the survey, all participants were provided with: (1) 36 cards, each containing a statement and its number, (2) a guide bar with a quasi-normal distribution (Figure 6-2), and (3) an answer sheet to record the rank ordering. They were then instructed to read all statements, sort the cards according to the extent to which they disagreed or agreed with them (-4 to +4) and to place the cards on the guide bar. Participants were also interviewed about their own experience of citrus farming, current problems and opinions about BMPs.

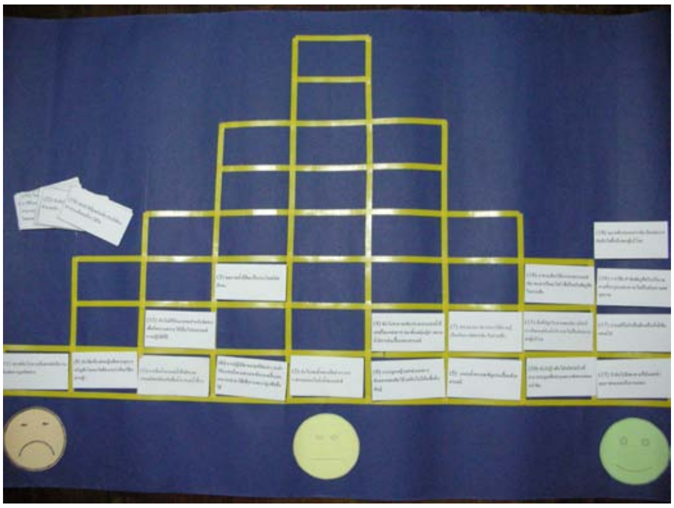

Figure 6-2: Survey tools

Notes: 1) A guide bar for 36 statements, and examples of the sorted statements (i.e. white cards)
2) Images of smiley face were used instead of typed ratings (i.e. very agree through to very disagree)

6.4 Data Analysis

Each participant's Q-sort was entered into a database using PQMETHOD software (Schmolck 2002). Initially, a correlation matrix of Q-sorts was analysed using principal components analysis. The analysis provided eight unrotated factors with eigenvalues > 1.0. Next, a Varimax rotation was used to rotate the factors, thereby investigating a two, three, four, five, six, seven and eight factor solution. The four factor solution produced the most statistically defensible model providing a uniquely satisfactory account of the data. Thus, this study reveals four factor groups or discourses.

In order to assign Q-sorts to the most appropriate factor, the factor loading of each Q-sort was considered. Loadings were considered statistically significant at the 0.01 level if they were approximately 2.58 times the standard error (SE) (Brown 1991). The standard error for a factor loading was derived from $1/\sqrt{N}$, where N equals the number of statements (Brown 1991). In this case, with 36 statements, the SE = $1/\sqrt{36}$ = 0.17. Thus, Q-sorts with either a positive or negative loading on a single factor in excess of 2.58(SE) = 2.58(0.17) = 0.44 were considered to load significantly on that relevant factor. Seven sorts did not load onto any of the four factors and they are thus excluded from further analysis (see Annex 10, Loadings).

6.5 Results

6.5.1 Interpreting factor arrays

The interpretation of the factors is based on statement scores. The statement score was first computed as a z-score, and then converted into the original Q-sort value format (score -4 to +4) for ease of interpretation (Watts and Stenner 2005) (see Annex 10, Distinguishing statements). Here, particular attention is given to statements that distinguish between factors and those statements that were ranked at the extremes of the scale (+4, +3, -3 and -4; Table 6-2). Positive scores indicate that a farmer would agree with that particular statement, whilst negative scores indicate disagreement. Participants' comments from the post-sorting interviews were also incorporated in the factor interpretation. The four factors are labelled as conservationist, traditionalist, disinterested and risk-averse.

Table 6-2: Factor Q-sort value (-4 to 4) for each statement

No.	Statements	Factors			
		A	B	C	D
1	Our water here is as safe to drink as anywhere in the country	-4	-4**	0*	-4
2	I have never discharged waste into natural watercourses	1*	4	-1*	4
3	Good water quality is a social benefit	4	3	3*	3
4	I can no longer fish from river that used to be a food source for a decade	0*	-2*	-1*	-2*
5	Natural watercourses are contaminated with chemicals	0*	-3	-3	-1*
6	If I adopt BMPs, the natural watercourse will be cleaner and water can be re-used for planting other crops	3	3	3	3
7	Government agencies should provide advisory services on soil management	3	3	1	0
8	To control weeds and grass, I prefer to use a power lawnmower than herbicides	3	2	2	1*
9	Vetiver (local plant) can stabilise farm ditches, but I cannot afford to buy the plants	0**	2**	0*	-2*
10	I do not know which tree could reduce soil erosion effects	-1	0*	-1	-3*
11	Soil on my farm is easily eroded	-1*	-3	-2	-3
12	I do not have enough land to allocate to BMP activities	-1	-1	0**	-2*
13	Chemically sprayed citrus from my farm is safe to eat	-2*	1	2	2
14	We should use organic substances instead of chemical pesticides on citrus farms	2	2	2	-1*
15	If I do not apply pesticide as I have been accustomed to do, the fruit quality may drop	-3*	2*	1	0
16	Applying the dosage of chemicals suggested on the label will not harm human health	-3*	1	0*	1
17	Chemicals do not always imply toxicity	-1	-2	-1	0*
18	Chemical-free labels on food are important for consumer purchasing decisions	2**	1	1	0
19	I tend to use fertilisers that are widely used by my neighbours	-2	1	1	-1
20	An application of organic fertiliser rather than chemicals will reduce pollution	2**	1	3**	1
21	The application of organic fertiliser will give better fruit quality	0**	-1*	2**	0**
22	I am happy to use fertilisers introduced by agricultural input retailers	-3	-1	-2	-3
23	Farmers should apply the right amount of fertiliser to match the trees' need because over-application will harm the environment	1	-1*	1	2
24	Without an application of chemical fertiliser, trees do not provide good yield	-2*	0	0	1
25	BMPs are needed to stop fighting between citrus farmers and residents	1	0	-1	1
26	Man cause pollutant emission, therefore we should take some actions to lessen pollution.	2*	0	0	0
27	Farmers can comply with BMPs if they get enough monetary support from government	1	1	4*	2*
28	My neighbours will support me if I adopt BMPs	0**	0*	1	1
29	We can gain more watershed benefits if we can restrict pollution from our farm production	1**	0**	0*	3*
30	In the long run, BMPs help enhance competitiveness in terms of chemical-free product	1	-1*	0**	2
31	The BMPs will lead to more red-tape, but I can adopt them despite this	0	-3*	-1	0
32	We should restrict citrus cultivation to designated areas	0	0	-3*	-1
33	Labour requirement for BMPs is a big problem	-1**	-2**	-3*	0*
34	We could not introduce BMPs correctly because we do not have enough understanding	-2	-2	-2	-1**
35	Most citrus farmers are not aware of water availability in the watershed	-1**	-1	-4*	-2
36	I cannot adopt BMPs because I do not have enough funds	0	0	-2*	-1

Note: Reading the table by column reveals the comparative ranking of statements which characterize a particular factor, and reading the table by row reveals the comparative ranking of a corresponding statement across all the factors. *p < 0 .01, **p < 0.05

Factor A: conservationist

Fifteen participants, both upstream and downstream farmers, loaded on the conservationist factor. This discourse represents a position that is pragmatic, moderately progressive and environmentally favourable. The main aspect of this discourse is the belief that ‘good quality of environment brings better quality of life’.

Those associated with the conservationist factor group explicitly expressed a preference for the production of safe and good quality products through environmentally friendly practices (statement 15, score -3; statement 24, -2). They also demonstrated an interest in minimizing adverse impacts on health and the environment (statement 13, -2; statement 16, -3; statement 20, +2). Further, this discourse was the only group expressing a belief that chemical-free labels on food items potentially affect consumers’ buying decisions (statement 18, +2).

In terms of water resource issues, this discourse represents a viewpoint that is indifferent in terms of perceptions about the current water quality (statement 4, 0; statement 5, 0; Table 2), but farmers in this group stated their awareness of water availability in the watershed (statement 35, -1). Further, this group of farmers was relatively confident that more watershed benefits will be gained from BMP adoption (statement 29, +1). Some of them also commented during the interviews that government should promote the concept of watershed services and benefits of BMP adoption to induce behavioural change amongst citrus farmers. This farmer group also believed that everyone was responsible for taking care of water resources (statement 26, +2). Moreover, farmers associated with this discourse not only expressed strong environmental concern, but also presented themselves as environmental protectors (statement 2, +1).

Those farmers associated with this discourse did not perceive there to be a problem with soil erosion on their farms (statement 11, -1), neither were they concerned about labour requirements being a limitation for BMP adoption (statement 33, -1). However, these statements were ranked relatively less negatively than by other groups. Additionally, farmers represented by this discourse expressed neutral viewpoints towards BMP adoption in many aspects. For example, they did not have strong opinions about the consistency of the quality provided by organic fertiliser (statement 21, 0), or the readiness of their fellow citizens to participate in more eco-friendly practices (statement 28, 0). Further, farmers represented by this factor group did not explicitly express whether they could afford to buy local plants to control soil stability (statement 9, 0). However, the interviews suggested that farmers needed advisory support from extension agents in order to achieve better outcomes in soil management.

Conservationists favoured conservation-oriented farming methods because they perceived the necessity of improving human and environmental health. Indeed discussions during farm interviews revealed that farmers had learned through trial and error to use smaller amounts of chemicals but still maintained fruit quality. Overall, the extent of awareness of eco-friendly production of this farmer group was relatively high.

Factor B: traditionalist

Sixteen participants loaded on the traditionalist factor; almost all were from downstream areas. This discourse featured farmers who felt comfortable in their current situation. The views represented by this discourse were characterized by a resistance to change that was underlined by a lack of open-mindedness to the wider world.

Those farmers in this group perceived that water quality was being threatened (statement 1, -4), but believed that this situation was bearable as water was classed as fishable (statement 4, -2). The resistance to change mainly came from a satisfaction with current agricultural practice which relied on chemicals in order to maintain fruit quality (statement 15, +2; statement 21, -1; statement 23, -1). Farmers commented during the interviews that size-graded and good-looking fruit could command higher prices. In other words, chemical-sprayed citrus simply meant guaranteed returns and secure family farming.

The traditionalists also defined other limitations that deterred BMP adoption. These were a lack of faith in the market for eco-friendly products (statement 30, -1), and uncertainty over external uncontrollable factors such as governmental procedure (statement 31, -3). Interviews revealed that some of the farmers in this group did not feel comfortable with strict government regulations such as enrolment procedures, and paperwork. However, it was evident that finding workers for labour-intensive practices was not a problem for BMP adoption (statement 33, -2).

As recorded during the interviews, farmers in this discourse had been informed about the use of local plants to stop runoff and maintain soil stabilization (statement 9, +2). However, this contradicts the neutral opinion expressed about the received wisdom and prevailing perceptions of erosion control (statement 10, 0). Further, farmers in this group also expressed neutral viewpoints about uncertainty of environmental gains from BMP adoption (statement 29, 0) and being socially excluded by non-adopters who were in mainstream agricultural practices (statement 28, 0). However, post-sort interviews with farmers revealed that some of them were afraid of being excluded from cultural and economic processes, and of losing informal support networks.

Farmers in this group showed less interest in applying new techniques and preferred current farming practice. As long as current practices provided the main source of livelihood for their family and high uncertainty about adoption of BMPs still prevailed, new production techniques that deviated from the current practice of farming and ways of life would not easily be accepted.

Factor C: disinterested

Seventeen participants loaded on the disinterested factor; almost all participants were downstream farmers. This perspective is characterized by a recognition of resource degradation, self-regard and a distinctive demand for short-term returns. This group was facing lower yields and poorer quality of fruit as a result of pest and disease epidemics.

The views of this group were strongly focused on water availability for crop production and food sources (statement 35, -4; statement 4, -1), undoubtedly because citrus production requires a huge amount of water. Though this group did not express strong opinions about water quality degradation (statement 1, 0), farmers perceived good water quality as a social benefit (statement 3, +3). However, statement 3 was statistically distinguished by having the lowest z-score when compared to the z-scores from the other discourses (Q-sort value format, z-score: +4, 1.98; +3, 1.90; +3, 1.26; +3, 1.77). In other words, those represented by this discourse least agreed with this statement of all groups.

Farmers in this group agreed that sustainability could be promoted through the use of organic substances (statement 20, +3; statement 21, 2), but were likely to prefer farming methods that contributed to nonpoint source pollution (statement 2, -1). The interviews revealed that chemical-sprayed fruit was produced in large quantities in order to keep up fruit appearances to meet with consumer demand. Another important viewpoint was found in opinions of citrus zoning, of which this group was not in favour (statement 32, -3). In Thailand, crop zoning aims to delineate a suitable area for each important crop in each watershed boundary. With zoning, appropriate technologies and management such as good agricultural practices can be applied to the particular growing area. Disagreement with the practice of crop zoning may imply an unwillingness to change current agricultural activities.

One key viewpoint of this group of farmers was the perception that funds from government were essential for starting a BMP scheme (statement 27, +4). This was despite the fact that this group possessed fundamental resources such as labour (statement 33, -3), and funds (statement 36, -2). Additionally, there were a few statements with which this discourse had a neutral viewpoint. These were related to the use of local plants to stabilize soil (statement 9, 0), the availability of land for allocation to BMPs (statement 12, 0), impacts of chemical applications on human health (statement 16, 0), likely environmental gains from adoption of BMPs (statement 29, 0) and the likelihood that BMPs will increase competitiveness by supplying a market for eco-friendly products (statement 30, 0).

The farming of this farmer group was economically non-viable, presumably because of an extensive use of chemicals. Moreover, this group strongly expressed the view that financial support from the government was required to start BMPs. Interviews revealed that this money was viewed as a viable tool to promote opportunities in family farming and to secure farm income. In terms of government action, this requirement signals that this farmer group was likely to create better watershed services if reasonable incentives were offered.

Factor D: risk-averse

Seventeen participants loaded on the risk-averse factor. This group featured farmers with the largest average farm size and almost all participants were from upstream areas where the arguments over air pollution and excessive water consumption were always at the top of the agenda. The farmers in this group were market-sensitive, and well informed. However, they had doubts about the net gains from adoption, and thus refrained from implementation due to costs and fear of economic losses.

Those associated with this discourse acknowledged that there were social benefits from farm pollution restrictions (statement 29, +3), and preferred to apply more eco-friendly practices in farm management (statement 8, +1). The group was also equipped with environmental management knowledge (statement 10, -3; statement 34, -1) and displayed a capacity to allocate land to meet with BMPs criteria (statement 12, -2). However, during interviews, some citrus farmers expressed a refusal to divide their own land for vegetative and structural practices (i.e. buffer zones and onsite retention storage) because they felt that too much land was required and investment costs were high.

Another viewpoint found within this discourse was related to the perception of the current condition of water resources. Those represented by this discourse did not consider that water quality was being threatened (statement 4, -2; statement 5, -1). Thus if they must comply with the policy on BMPs, an amount of monetary support was requested from the government (statement 27, +2). This was to secure income and to comply with the regulation if particular materials, such as local plants to control soil erosion, were required (statement 9, -2).

Further, farmers in this discourse were reluctant to change their current practices. This resistance came from existing attitudes towards chemical use which were compounded by a disagreement that chemicals could be effectively substituted by organic substances (statement 14, -1). During the post-sort interviews some citrus farmers asserted that consumers bought fruit depending on its product attributes such as physical appearance, rather than production attributes. Thus, the farmers inevitably applied chemicals. They also stated that the government should promote and launch a campaign to raise consumer awareness of chemical-free fruit. Those farmers associated with this discourse displayed neutral viewpoints towards several statements. The group neither agreed nor disagreed about the role of organic fertiliser in boosting fruit quality (statement 21, 0), or about labour requirement being a limitation to BMP uptake (statement 33, 0). Additionally, farmers associated with this discourse expressed a neutral viewpoint about the toxicity of chemicals (statement 17, 0).

This farmer group held a positive attitude towards eco-friendly management, but refused to change. This is because farmers viewed BMP adoption as a risky activity, in that their wealth rested on the success of innovation. This fitted with a managerial profile which emphasizes the goal of reducing variation in income, and gives environmental protection a lower priority than the economics of the farm business.

6.5.2 Consensus statement

There are points of consensus amongst all four factors. One statement that received a statistically indistinguishable z-score and that all factors ranked in the same direction (score +3) is statement 6 (Table 6-2; see Annex 10, Consensus statement). All groups agreed that if they adopted BMPs, natural watercourses would be cleaner and could then be safely re-used for planting other crops. This consensus statement suggests that citrus farmers perceived natural water resources as economic goods, and essential assets in farming. This is unquestionably because citrus production demands huge amounts of water and the cost of water acquirement is relatively high in terms of effective irrigation systems such as sprinklers. Furthermore, citrus farmers had experienced conflict over excessive water consumption amongst various water users in the watershed, as well as arguments between farmers and local residents in the critical areas. Therefore, they tended to believe that BMPs could help solve these existing conflicts through less-polluted water and water recycling.

6.6 Discussion

The bottom-up results from Q-Methodology can provide policymakers with information for sustainable policy development. However, caution is needed when policymakers target different programmes to different farmer groups. For example, the traditionalist and disinterested groups are mainly downstream farmers, while almost all of the risk-averse farmers are upstream farmers with relatively large farms; however assuming that these particular characteristics are likely to be consistently defining variables may not be justified (Raje 2007). There were some downstream farmers who were represented by other discourses, thus being a downstream farmer was not the only reason for being defined as a traditionalist or disinterested. Similarly, there were some large-scale upstream farmers who did not load on the risk-averse discourse. In conclusion, farmers in the Ping river basin held a number of perspectives towards BMPs, but these were not consistently related to farm or farmer characteristics. Q-Methodology is not an approach that aims to identify certain socioeconomic groups and their associated views. Rather, Q-Methodology can be used to identify what different perspectives exist and also what farmers share as common perspectives about BMP uptake.

Further, as participants in the Q-study were not randomly selected, the reliable generalisations about farm or farmer characteristics cannot be made (Danielson 2009). However, Q-Methodology facilitates decision-making by highlighting relatively important attitudes about the topic being studied (Durning and Brown 2006). A few dominant concerns do emerge and provide some insights relating to the key factors affecting potential BMP adoption. Policy interventions may need to vary group by group. Different instruments will have varying success within different groups given the variation in the motivations and interests across groups (Davies and Hodge 2007).

6.7 Summary

An application of Q-Methodology aims to understand farmers' attitudes and to identify the ways environmental issues are perceived. Evidences from Q-Methodology are expected to enrich findings from the TPB and econometric estimation analysis by mapping the different perspectives of citrus farmers relating to BMP uptake. The first step in Q-Methodology was to develop a concourse and to establish the Q-Sample. In this study, concourse was gathered from personal interviews and published materials such as newspaper, public hearings and government reports. A concourse of 419 statements was derived. These statements were categorised by a data matrix and 36 statements were drawn from the concourse.

Seventy two participants were purposively selected from the sample set from the TPB study. The participants included 51% of upstream farmers and 49% of downstream farmers. The Q-sorting was conducted during winter 2007/2008 and summer 2008. Data were analysed using factor analysis and factor rotation provided by the PQMETHOD software. Findings revealed a diverse range of opinions and determined salient beliefs toward BMP uptake. The four-factor solution gave the most coherent explanation with 48% of total variance. These four distinct groups were then labelled according to their main characteristics, and these were conservationist, traditionalist, disinterested and risk-averse.

In short, the conservationist is pragmatic, moderately progressive and environmentally favourable. The traditionalist tends to resist BMP adoption. This is signalled by a lack of self-confidence and narrow-minded views toward policy changes. The disinterested recognises a state of natural resource degradation, but shows a distinctive demand for short-term returns to compensate for current losses from farming. The risk-averse is market-sensitive and it refrains from BMP adoption because of fear of economic losses. Though four groups hold different subjectivities in their attitudes toward BMP uptake, there are parts of consensus. The consensus suggests that farmers perceive natural water resources as economic goods and essential assets in farming. Viewpoints of these four groups can then be used to deepen understanding about perceptions of BMP adoption and lead to policy design.

In sum, Q-Methodology is an alternative method to assess human subjectivity in a systematic way. Furthermore, it would help modify the assumptions of objectivism underlying the R-Method typically used by traditional economists. In this study the strengths of Q-Methodology are that it allows farmers to model their own attitudes, and it preserves self-referent factors during a statistical analysis. Evidences from this study reveal that important beliefs are different from group to group. This in turn implies that a well-designed policy to meet with the needs and desires of the farmers potentially increases participation.

7 KEY FINDINGS AND POLICY IMPLICATIONS

This thesis offers three independent studies on BMP adoption. Each of which has its own stand-alone value, and provides meaningful information for policy implications. This chapter outlines the key findings from each study and presents policy implications by linking the study findings to the literature on PES (Figure 7-1). Section 7.1 summarises the key findings from each independent study and methodological findings. These findings provide information for a discussion regarding the development of water-related PES programmes in section 7.2. The policy implications are presented in section 7.3. The lessons learned from the findings in terms of nonpoint source pollution management are discussed in section 7.4, followed by the methodological limitations and recommendations for future research in section 7.5. Section 7.6 presents 'a way forward' focusing on future actions the government should consider in order to develop a PES programme in Thailand.

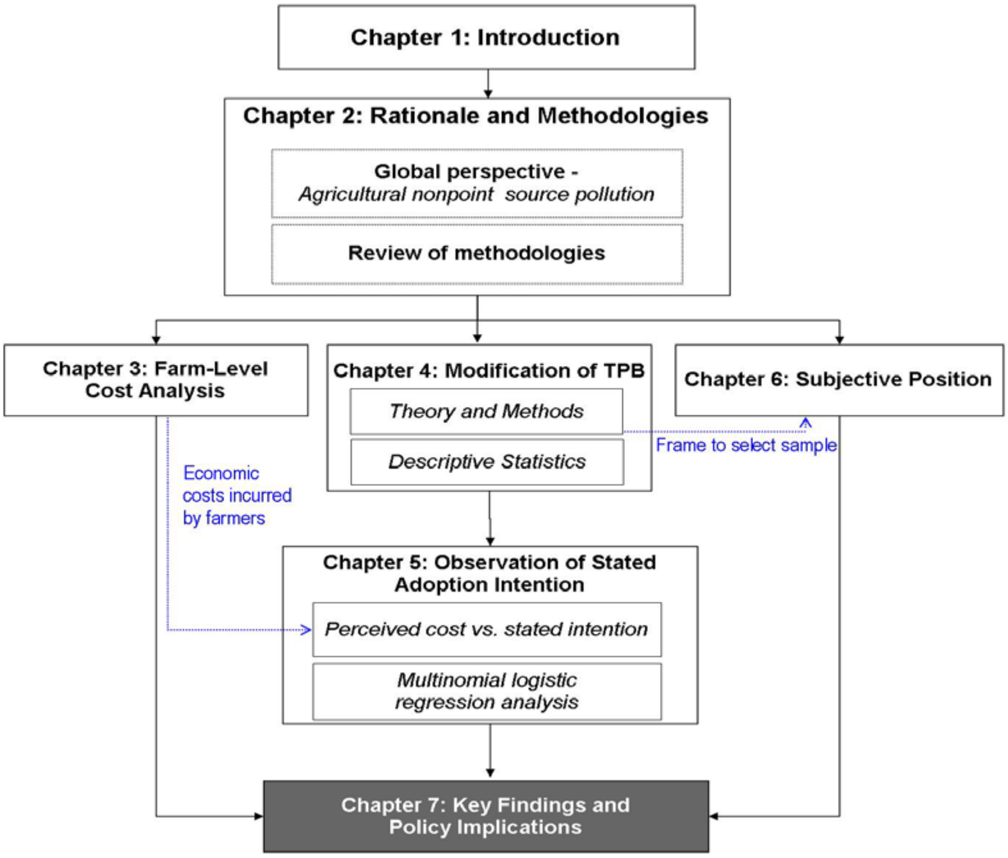

Figure 7-1: Thesis structure

7.1 Summary of Findings

The analysis presented in the preceding chapters has highlighted the state of BMP adoption in citrus farms in the Ping river basin. In chapter 3, the study on costs incurred to farmers demonstrated cost components of twelve BMPs. In chapter 4, using the data collected between December 2007 and August 2008, an empirical model based on the TPB was applied to investigate farmers' adoption intentions and descriptive statistics were presented. In chapter 5, the cost information from chapter 3 provided information for the study of how perceived costs could affect farmers' stated intentions. Moreover, data from chapter 4 were modelled with a logistic regression analysis to explore the significant factors influencing adoption intentions. In chapter 6, Q-Methodology was employed to define salient attitudes towards the adoption decision. In this chapter, the results from the above mentioned studies are discussed in the context of available PES literature. This offers insights into policy implications for a water-related PES programme.

7.1.1 Key findings from the independent studies

7.1.1.1 Farm-Level Cost Analysis

Influence of perceived costs on adoption intention

The observation of the relationship between perceived costs and stated intention to adopt a particular BMP is partially relevant to the results from the TPB model and Q-Methodology, and it suggests three main findings. First, from the farmers' viewpoint, land opportunity cost can be a critical determinant when selecting BMPs. This is because a perception of high opportunity cost potentially affects perceived profitability. Neill and Lee (2001) argue that an adoption of new technology is likely to take place if alternative land uses are more economically viable. Similarly, Pannell (2003) stated that since benefits of BMP adoption are not always apparent and provided the minimum scale of land needed to trial BMP is large, these could deter farmers' adoption. The conclusion that land opportunity cost is a barrier for adoption of a certain BMP is not only derived from the farm-cost study, but it is also evident in the TPB model and Q-Methodology studies, in that BMPs with large land opportunity cost are less preferred.

Second, perceived cost plays an essential part in decision-making, but it may not be the most important determinant in farmers' adoption intentions. This conclusion is also supported by the TPB and its empirical analysis. In the TPB model, the elicitation study, which provided qualitative data, was conducted to determine psychological factors influencing BMP adoption. Affordability (PBC1), reflecting farmers' perceived costs, was one of the most frequently stated factors, and it was incorporated in a logistic regression as an independent variable. In the stepwise analysis, affordability was firstly entered into the equation, but it was then removed from the equation in the final step. In this sense, from farmers' viewpoints, affordability (or perceived cost) could be viewed as an important factor affecting their adoption decisions, but it is statistically nonsignificant when other predictors were taken into consideration. Furthermore, although the economic cost analysis at farm-level showed that BMPs with low investment cost were preferred to those with relatively high cost, there was no definite conclusion regarding the relationship between perceived costs and stated intentions. For example, though Structural Practices are not financially attractive and have a high opportunity cost, they were preferred by a number of farmers.

The last observation is that farmers are likely to adopt the practice they perceive that the benefits outweigh the costs. This is supported by the finding that soil analysis is the most preferred BMP. This finding is consistent with the work of Rolfe et al. (2008) who found that nutrient management was favoured by farmers because the perceived benefits, such as input use reduction, exceeded perceived implementation costs. However, this could raise an argument regarding the influence of perceived cost, because it varies across farmers and whether farmers adopt a new technology partially depends on their personal attitudes towards conservation practices (Gelso et al. 2008). Thus, holding all other relevant factors constant, that farmers will adopt practices producing higher benefits relative to costs is true only if farmers easily distinguish costs between several BMPs.

Indication for payment

Cost components of BMP are divided into two main categories. These are installation and annual maintenance costs, and land opportunity cost. The investigation on the cost differences amongst twelve BMPs highlights the significance of land opportunity cost as it shares the largest proportion in BMP cost structure. This is followed by installation costs that occur in the first year and annual maintenance costs. The information regarding cost component is useful for designing a PES programme. In the context of PES programmes, payments per ha are the same for all service providers adopting a given practice. Thus, the critical factors that differentially affect farmers' ability to participate in BMP programme are on the cost side (Pagiola et al. 2005). The observation on costs can signal a fair compensation for land converted to conservation practices, and thus increase participation rates.

7.1.1.2 An extension of the TPB model

Preference towards Good Husbandry

Due to the fact that BMPs are site-specific, in this thesis farmers were presented with twelve BMPs. Farmers were asked to select the top three BMPs that they wanted to adopt in their farms. The results in chapter 4 show that Good Husbandry is preferred to Vegetative and Structural Practices. There are a few reasons why Good Husbandry is more attractive than other BMP categories. These are detailed as follows:

1. Good Husbandry offers a few advantages over other functional categories. For example, it can be trialled on a small-scale for learning process, and its effects are observable in a shorter time compared to other BMP categories.
2. In Thailand there is legislation that prohibits certain actions in farm management. For example, farmers are not allowed to farm in a former forest reserve. They must hold an utilisation certificate, but they are restricted with some land use regulations, such as extensive earthworks. This could be a barrier to the adoption of Vegetative and Structural Practices.
3. Vegetative and Structural Practices may not be compatible with existing farm layout or operations. Thus, farmers perceive an increase of overall complexity in land management system from their adoption.

The most preferred BMP

The results illustrated that soil analysis is the most preferred BMP amongst farmers. Soil analysis is defined in this thesis as a test of organic matters and fertiliser application, particularly organic fertiliser, to match the need of crops. It is found that one-third of farmers stated their intentions to adopt this BMP in their farms. This is because farmers perceive that adoption can lead to a reduction in production cost, and prevent future loss in farm profit. Further, the adoption of soil analysis is flexible and can be adopted in any farm site.

Contribution of psychological variables to economic behaviour

Economic decision models offer an understanding of factors affecting adoption, whereas psychological constructs explain how such adoption is translated into decision-making (Montoya et al. 2000). Failure to incorporate these two disciplines into the behaviour study could result in a welfare distortion of agri-environmental policy. This is because parts of individuals' behaviour is unbounded rationally, but policy is often made based on a bounded rationality assumption (Guagnano et al. 1995). In this thesis, BMPs lend themselves to the construction and application of TPB. The inclusion of TPB in this thesis is to induce behavioural, i.e. psychological, variables into the model. This can provide a better explanation and prediction of economic phenomena (BMP adoption). The importance of psychological variables in economic behaviour is supported by the findings from the empirical model. The M-W test helps in explaining the rationales behind farmers' differences. It was used to find how farmers' psychological variables (or thought processes) differ and to compare external conditions between upstream and downstream farmers. Moreover, results from the multinomial logistic regression analysis indicate that both psychological and economic perspectives are critical determinants for understanding why farmers adopt conservative practices. Thus, policymakers should take into account the value, belief and incentive of target population when implementing policies.

Reference points to increase farmers' participation

The TPB model explicitly hypothesises behavioural intention to be an immediate determinant of behaviour, and further suggests that psychological determinants can serve as a point of attack to induce targeted behaviour (Ajzen 1991: 206). The logistic regression analysis in chapter 5 included a set of psychological variables and additional variables to increase the predictive power to the model. Results have shown that the likelihood of adopting BMPs was associated with farm size, contribution of family labours in farm, access to information sources apart from government agencies, and dependency on other crops. Moreover, two significant psychological determinants were farmers' attitudes towards consumers and farmers' perceived farm returns.

In this thesis, there are two ways the TPB and its regression analysis could inform government intervention. First, the results suggest which specific psychological determinants should be addressed. Knowing the important beliefs that underlie farmers' attitudes, a government can pay attention to these salient beliefs and design interventions to increase the adoption rate. For example, the results show that perception about farm returns is a significant barrier to BMP adoption. As fixed investments and significant capital layout are required, incentive systems could be considered to keep farmers engaged (Fielding et al. 2005). Furthermore, consumers are the major referents influencing adoption intention, channelling of information through customers is likely to be an indirect motivation to increase farmers' participation. Figure 7-2 illustrates supply chains delivering citrus to consumers. An understanding in a delivery path could elaborate how marketing campaign is used to raise awareness amongst consumers.

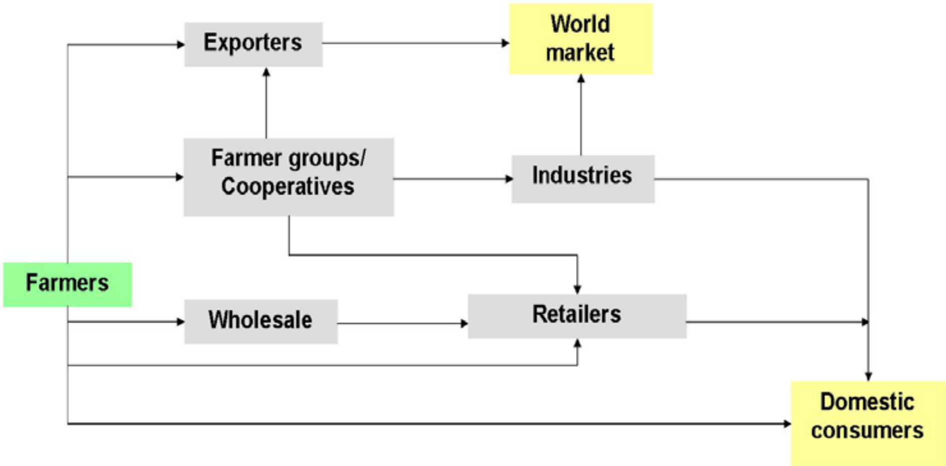

Figure 7-2: Marketing channels

Obviously, the most direct and simple sale is when the farmers sell their fruit directly to consumers. Farmers peddle their fruit from house to house, or consumers go to buy at the farms. Fruit is also delieverd through retailers, such as supermarket, fresh market, and a peddler. The upstream channels of retailer can be farmers themselves, wholesalers, or farmer groups/ cooperatives. A considerable amount of citrus also goes to citrus processing plant or is packed for export.

Consumers' food choice is influenced by taste and appearance, health, convenience, and process (Brunso et al. 2002). At the attribute level BMP-processed fruit shows a striking difference; for example, its contribution to environmental conservation when judging in comparison with commercial fruit. However, there is a knowledge gap between farmers and consumers because consumers become increasingly distanced in terms of time, space and experience from the farm and production process (Jaffe and Gertler 2006). Bignebat et al. (2009) argued that intermediaries, such as retailers, may either help or hinder transmitting of imformation as they play an important role in making products available to consumers. As such, stimulating consumer demand by creating the images linked to the production value is a key to success, and marketing campaign needs to integrate this value in the purchasing behaviour (Horlings 2009).

Second, the analysis indicates that the influence of additional determinants on adoption intentions is attributed to backgrounds of farmers. Farmers with different backgrounds prefer to adopt different BMP categories. Policymakers can consider these additional determinants as an entry point for policy intervention, such as the criteria to set minimum requirements for farmers and farms participating in a PES programme.

7.1.1.3 Q-Methodology

Farmer's attitudes – differences and similarities

The application of Q-Methodology in chapter 6 helps to understand why farmers behave the way they do, how opinions and attitudes are formed, how farmers were or will be affected by the policies, and the differences between farmer groups. Q results enrich findings from the TPB study by illustrating different farmers' perspectives in relation to BMP uptake. During the analysis and the interpretation of salient statements, four farmer groups were revealed. These were conservationist, traditionalist, disinterested, and risk-averse (Figure 7-3). Empirical work suggests that an attitude study is important for implementing policy (Tjernstrom and Tietenberg 2008), in that psychological segmentation facilitates policies designed to remove adoption barriers which typically vary across farmers (Pannell et al. 2006).

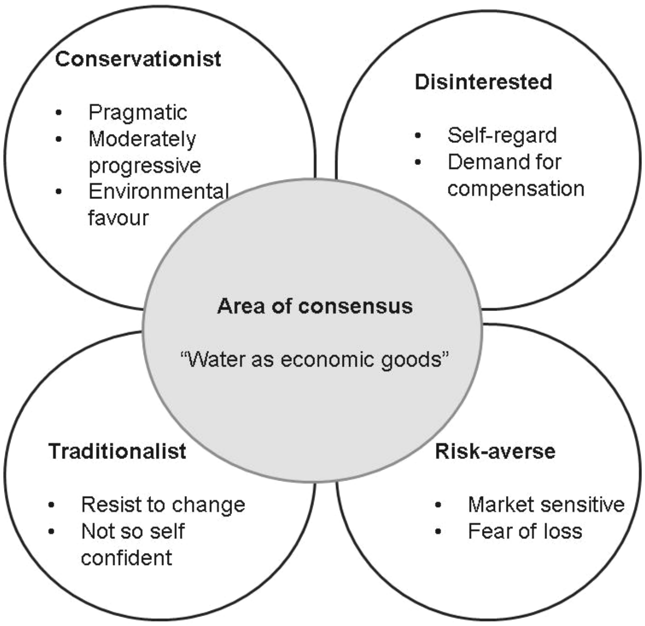

Figure 7-3: Main characteristics of each group and consensus area

Though the four farmer groups suggest that there is a wide variety of farmers' attitudes towards BMP adoption, there is an area of consensus where all farmers perceive a positive aspect of BMP (Figure 7-3). All groups agreed that if they adopted BMPs, natural watercourses would be cleaner and could then be safely re-used for planting other crops. This agreement points toward an opportunity to promote BMPs as farmers generally hold positive environmental values regarding water resources and perceive water as an economic goods. In sum, Q results highlight different perspectives and offer insights into how much differences are constructed. Furthermore, Q study provides the information of what different perspectives exist and what farmers share as a common perspective about BMP uptake.

Q results and policy implications

As suggested by Swedeen (2006), results from Q study could benefit policy implications in two ways. First, different management alternatives could be constructed for each discourse. Cools et al. (2009) find that segmentation can identify target groups according to a variety of meaningful variables and helps to develop practical guides that are appropriate for each group. Second, policy could target at shared perspectives or consensus. Consensus may be of interest to the government as a set of values with which to promote a unifying management concept (Steelman and Maguire 1999).

i) Policies targeting at each discourse

Q-Methodology has revealed four farmer groups holding relatively different perspectives. The Q results point to the important constraints and concerns that are not always acknowledged, when making policy based on the assumption that farmers have the goal of profit maximisation. Having captured concerns of these farmers, barriers to BMP adoption can be defined (Table 7-1). A concern towards new policy adoption is known as a status-quo bias. It arises when an individual prefers the current position rather than changes in the provision of environmental commodities, and it can be reduced through removing uncertainties from adoption (Venkatachalam 2008). The concerns over BMP adoption could be useful for a policy design in this sense. In the following paragraphs, potential policy instruments to increase adoption for each discourse are discussed.

Table 7-1: Summarisation of characteristics and concerns from BMP adoption for each farmer group

Factor	Characteristics	Concerns about BMP adoption	Policy instruments
Factor A: conservationist	Pragmatic Moderately progressive Environmental favour	Consumer demand for chemical-free fruit Advisory support Gains from watershed services	Marketing campaign Education
Factor B: traditionalist	Shaped by traditional farming communities and farming culture Not so self confident Indifferent about the current condition	Fruit quality Insecure market Lack of flexibility Community exclusion	Marketing campaign Bureaucracy Information dissemination
Factor C: disinterested	Recognition in natural resource degradation Self-regard Demand for short term return	Compensation Insecure market	Market-based incentive Marketing campaign
Factor D: risk-averse	Sensitive to market Concerns over gains from adoption Fear of loss	Compensation Insecure market	Market-based incentive Marketing campaign
Area of consensus: perceptions that BMP adoption results in improved water quality, and water is economic goods			

Market-based incentive: the disinterested and risk-averse groups were concerned about the level of compensation to be paid for BMP uptake. To address this, adopting farmers should be compensated for producing the extra benefits that arise from BMPs, otherwise the externality will not be priced and market failure will follow (Sarker et al. 2008a). A market-based incentive of both cash and in-kind compensation could be offered to induce desirable behaviour (Dowd et al. 2008). For example, farmers may be compensated for capital installation costs or increased risk in terms of decreased yields over the first few years of implementation (Ribaudo et al. 1999).

Marketing campaign: while the conservationist realised there may be a potential market for eco-friendly products, the traditionalist, disinterested and risk-averse expressed doubts about there being a guaranteed market for chemical-free fruit and concerns about lower fruit quality if organic substances were applied. According to Oates (2006), Thai consumers find it difficult to distinguish between quality and safety labels, and many of them rely on certain retail chains rather than quality certification. Marketing campaigns to raise awareness about eco-friendly production processes could generate a price premium for sustainable citrus farming (Oates 2006). Such a campaign might help to assuage farmers' concerns about there not being a market for chemical-free produce, and, in turn, increase the likelihood of voluntary adoption for all farmer groups.

Bureaucracy: bureaucratic barriers and lack of flexibility, such as government regulations, paperwork requirements, participation and eligibility requirements, are some of the main concerns for the traditionalists. If BMPs are being promoted as a policy, the government should launch simple regulations and make procedures flexible in order to simplify communication between farmers and government (Kosoy et al. 2008).

Education: previous studies suggest that a lack of information about profitability and environmental benefit has deterred farmers from the adoption of proper management practices (FAO 2007b). This is supported by the interviews with the conservationists, who agreed that education could open the door to opportunity for every farmer. For example, science-based information could lower the risk perceptions of the risk-averse and enable the traditionalist and disinterested to improve their understanding about positive outcomes from adoption. Information could help to revise farmers' perceptions regarding the cost effectiveness of new farming practices and environmental benefits (Feather and Amacher 1994). Farmers should be informed that their farming depends on, and generates, a wide range of ecosystem services, including watershed services such as water flow and water quality. This can be done through training or extension workshops under the instruction of expert farmers (Brookfield and Gyasi 2009; Hashemi et al. 2008). Ramsey and Hungerford (2002) suggested that environmental education offered through the schooling system is critical for removing barriers to the adoption of more eco-friendly practices producing ecosystem services.

Information dissemination: traditionally, farm supply shops serve as a meeting place and information centre for Thai farmers (Oates 2006). Those who step out of mainstream farming could face significant social pressures, including being excluded by neighbours (de Buck et al. 2001). This was one of the concerns exposed during the post-sort interviews with traditionalists. Because supply shop retailers play an important role in information transfer, they could potentially provide extension services, for example acting as a BMP innovation dissemination point for farmers (FAO 1999; Fuwa and Sajise 2006).

ii) Policy targeting at a shared agreement

A few Q-studies focused on policy intervention targeting at shared values amongst all discourses. For example, Ockwell (2008) suggested that discussion to policy intervention could start with an area of consensus. Webler and Tuler (2001) argued that it is a challenge for policymakers to meet with different views and to design a process that meets shared needs. Similarly, Swedeen (2006) agreed that area of consensus serves as a basis for future work in developing a sustainable policy that is consented by all stakeholders.

In this study, the consensus statement represents the idea that water is economic goods and being a critical resource in citrus production (Table 7-1). This may suggest a point that relevant to the development and operation of a PES programme. Since PES programmes can be adopted as a business-type approach, offering a long-term environmental conservation (Bishop et al. 2006), this identifies an acceptable condition for a BMP adoption that would be compatible with farmers' shared value. In other words, the area of consensus suggests that promoting PES programme as a fair and viable agreement to sustain water quality could open up a possibility for dialogue to satisfy solutions amongst all farmer groups.

Overall, the Q results highlight farmers' constraints and interests. It also offers insights into social, political, economic, and technical perspectives that are fundamental elements of the farming. These perspectives are basic premises leading to a success of PES development (Perrot-Maître 2006). For example, the findings explicitly illustrate that cash alone is not sufficient to induce farmer's participation. This is in line with the existing PES programme in France, the Vittel water company providing incentives to upstream farmers to voluntarily change their farming practices. The key issue for the success of Vittle company is an incentive which taking into account the livelihood strategies of farm families and their long-term plans (Perrot-Maître 2006).

7.1.2 Methodological findings

Figure 7-4 illustrates the extent to which key findings can contribute to methodology and policy implications. In terms of methodological findings, there is a linkage between independent studies, in that the key findings from one independent study offer information for another independent study. First, the economic cost estimates provided cost figures for a graphical comparison to explore a relationship between perceived cost and farmers' adoption intentions. Second, a sample in the Q study has been drawn from the TPB participants. Methodological links between these independent studies are presented as follows.

First, previous studies (see for example: Rehman et al. 2007; Fielding et al. 2005) showed that a TPB-structured questionnaire could only contain perceived costs. As such, the TPB model could not explain how costs associate with behaviours. Alternatively, the influences of costs on adoption decision have been investigated through a graphical illustration. In this sense, the economic cost estimates were plotted against the frequency of stated intentions to adopt each BMP. Notably, the graph presentation might be criticised for the lack of details and accuracy regarding data interpretation. But, it is the second best method to present quantitative data when the regression method could not be done.

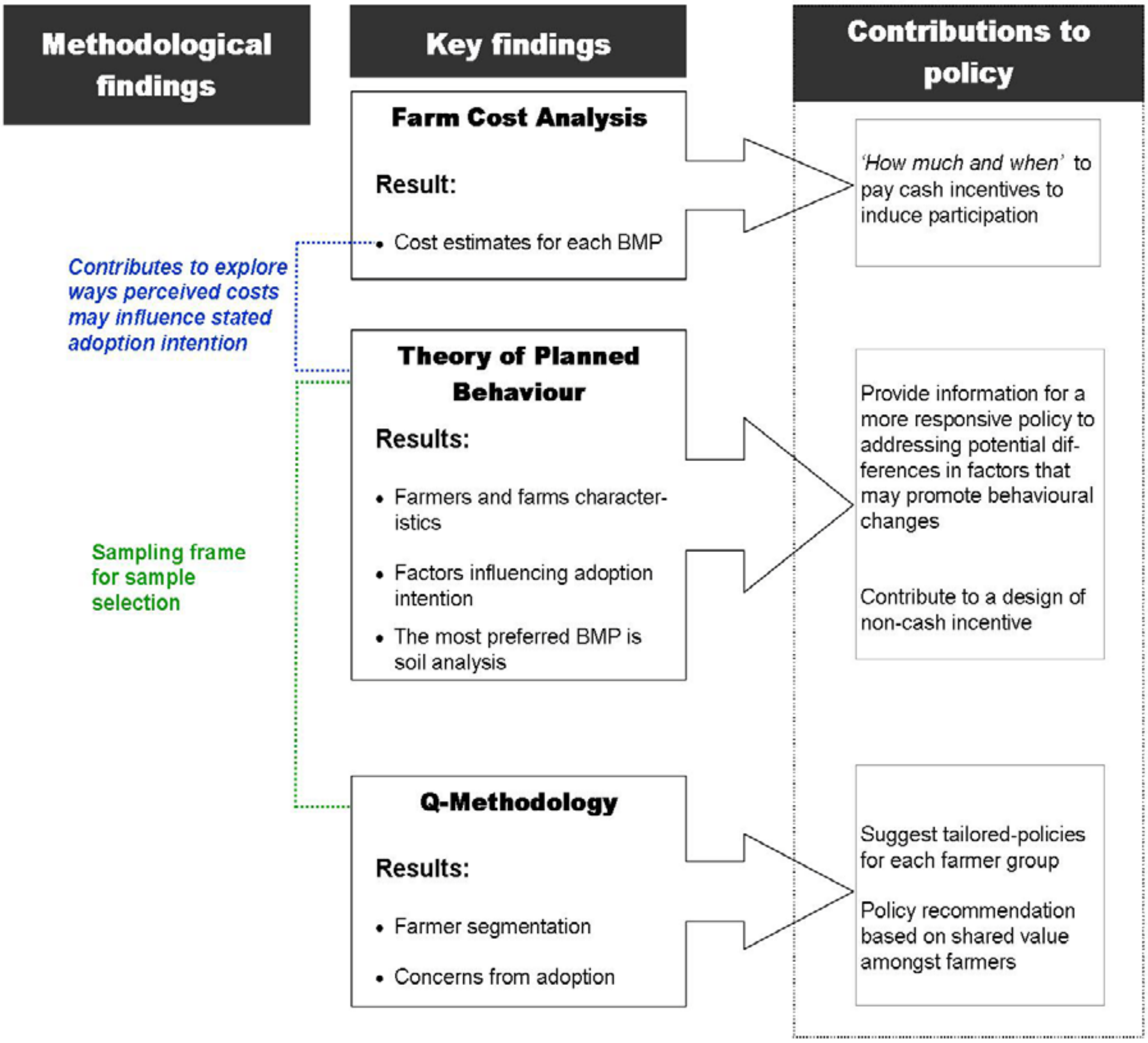

Figure 7-4: Key findings, contributions to methodology and policy implications

Second, the mechanism by which attitudes influence human's behaviour is described by the TPB model, while the Q-Methodology is an extended study to investigate how such attitudes have been formed. A sample in the Q study was selected by the researcher. The criterion is to select participants who are representatives of the population. This must ensure that a range from one extreme to the other is included. In this thesis, participants in the TPB study were used as sampling frame for the Q study. By doing so, the main advantage is that a TPB interview allows the researcher to pre-screen potential candidates from a pool of farmers.

Another point why this thesis has proposed the Q-Methodology after the TPB study relates to policy implications. Barker and Swift (2009) argued that rather than explicitly indicating the effective intervention, TPB results can provide just general guidelines for government intervention. TPB findings only suggest the importance of promoting supportive campaigns through a psychological construct and inform an early intervention programme by targeting directly to external factors. Therefore, policy implications can be done at a generic level by highlighting the key issues the policymakers should focus on. However, given a comprehensive perspective of human behaviour, tailored interventions would be more efficient than interventions directed at changing behaviour in a general population (de Bruijn et al. 2005). The challenge is to consider different types of farmers grouped by their attitudes. In an attempt to use the Q-Methodology, the psychological segmentation contributes to a more responsive and specific policy designed to remove adoption barriers which vary across farmers (Pannell et al. 2006). Moreover, the revealed consensus suggests that there is a potential to advance a PES programme as a mean to preserve water quality. This information is useful for policy implications as the PES programme is induced not only by transferred payment from beneficiaries to service sellers, but it also requires the existence of a 'pro-protection' attitude amongst service sellers, such as farmers (Vatn 2009).

7.2 Widening the PES Perspective and Contributions to Policy

This section discusses conditions for a design and development of water-related PES programmes. The discussion is based on findings which can contribute to PES literature. To answer the question of how to achieve PES, three main components of PES programme are considered. These are: i) the commodity; ii) institutional arrangement, including interplay between sellers, buyers and intermediary, and a legal framework to support the PES programme; and iii) payment mechanisms, addressing the issue of how the payment should be made, how much to be paid and when to do the transaction.

7.2.1 Commodity

One of the key conditions for PES programmes is that there should have a well-defined ecosystem service. This is important because the ecosystem service must be transformed into a commodity, which then can be exchanged for a payment. The Millennium Ecosystem Assessment (2005) states that cultivated land can deliver a regulating service of water purification by the process, such as removal of excess nutrients and pollutants. In terms of impaired water quality as a consequence of farm pollution, an efficient approach is needed to tackle the problem at the source of origin. Amongst several management tools, a series of BMPs are recommended to reduce the risk of farm pollution by intercepting, or preventing, pollutant before it reaches water bodies. Typically, PES programmes tie payments to the delivery of a service proxy rather than the service itself (Wunder et al. 2008; Landell-Mills and Porras 2002). In chapter 1, twelve BMPs were defined as commodities in the sense that they have been long perceived as contracts negotiated between service providers and downstream beneficiaries. Buyers purchase conservation practices adopted by service providers but they do not directly buy watershed services.

For example, the analysis in chapter 4 showed that soil analysis was the most preferred BMP amongst citrus farmers in the Ping river basin. From the supply side, this may imply that the soil analysis has a potential to be promoted as a commodity in the PES programme. However, the issue of which ecosystem service is defined as a commodity has importance beyond traditional commodity considerations, because it addresses the management of environmental resources and human well-being. This suggests that a biophysical model is needed to elucidate the link between ecosystem and its services (Daily et al. 2009). A simulation model is useful to investigate the scale effects of conservation practices, and the results can be fed into an economic model to measure the value services accruing to beneficiaries. This information is necessary in the design of PES programme, as it develops a baseline to assess PES additionality. The additionality is critical at the early development stage because PES is much more a demand-oriented programme requiring performance standard as the basis for programme decision-making (Smith 2006). In other words, the farm produces multi-services to buyers. To appoint appropriate commodity, policymakers must understand how well BMPs can be characterised with respect to their effects on ecosystem services. This is to ensure that positive impacts from the BMP adoption will occur, and that the water-related PES programme meets demand from service buyers.

7.2.2 Institutional arrangements

Wunder (2005) suggests that in the development of PES programme there needs to be institutions and laws that make provisions for and have capacity to effectively facilitate the transaction. This section aims to identify potential sellers and prospective buyers, to determine whether an intermediary is needed to facilitate a PES programme, and to look beyond the prevailing legislations whether they are sufficient for supporting a PES programme.

7.2.2.1 Prospective sellers, buyers, and intermediary

Figure 7-5 presents how the key findings from the three independent studies can be used to specify the potential sellers, buyers, and an intermediary in the PES programme.

Sellers

Citrus cultivation is one source of pollution in the Ping river basin. Impaired water quality as a result of farm pollution suggests that alternative measures are needed to tackle the problems of nonpoint source pollution at farm level. This thesis proposes that citrus farmers in the Ping river basin are potential sellers who can adopt BMPs in exchange for payments. The characteristics of sellers were described by descriptive statistics in chapter 4. Moreover, in chapter 5, the use of TPB with a multivariate logistic regression helps to explain complexities of farmers' behavioural intentions by identifying significant factors explaining the intention to adopt each BMP category, i.e. Good Husbandry, Vegetative Practice and Structural Practice. Further, Q study to understand differences and similarities in farmers' attitudes toward BMPs was offered in chapter 6. The findings from TPB and Q studies enable the understanding of stated intentions within each BMP category. They are also useful to set up eligibility requirements for participants, and suggest policy instruments to induce farmers' participation (Figure 7-5).

Findings from the logistic model and Q-Methodology suggested that the farmers' decisions were not only based on profit maximisation, but it was also influenced by internal factors, such as personal perceptions about ability, skills, and knowledge. This is in line with the conceptual framework proposed by the Millennium Ecosystem Assessment (2005). Based on the framework, indirect factors, such as cultural and socio-political forces indirectly drive changes in ecosystem services, and these factors may directly affect human well-being. The findings that internal factors are important to decision-making are necessary for the development of PES programme, because transfer payments can take on many forms from actual cash to technical assistance and in-kind compensation (Wunder et al. 2008). Knowing what are significant factors affecting adoption intentions and how farmers perceive BMPs, policymakers are able to design more effective policy to motivate farmers and increase the rate of voluntary participation.

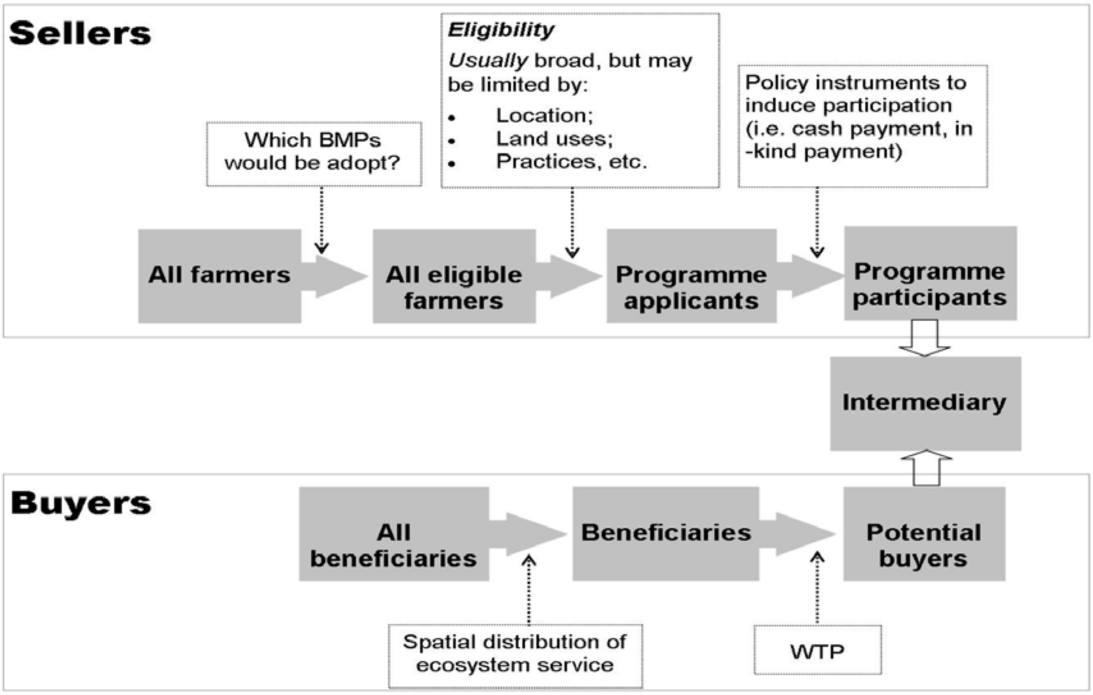

Figure 7-5: Criteria to define prospective buyers, sellers and an intermediary

Buyers

In the context of PES, a buyer is any stakeholder who recognises a change of ecosystem service provisions, and who can be morally, legally or rationally motivated to pay for such service provision (Suyanto et al. 2005). Lipper et al. (2009) identified three broad categories of buyers: public sector, private sector, and NGOs. The key to determine the source of payments is the type and distribution of benefits generated. The conceptual framework illustrating relationships and interactions between ecosystems and human well-being (Millennium Ecosystem Assessment 2005), and the spatial dimension of the external positive effects generated are useful to identify prospective buyers (Figure 7-5).

Wunder (2005) states that the beneficiaries will pay as long as the ecosystem service is provided. This condition is based on the additionality of the PES. Buyers will participate if they are confident that additional services, such as when reduced fertiliser rates are applied, are secured (UNESCAP 2009). To this point, in the long term, an individual buyer may not be willing to pay for a service. This gives room for a government to induce demand for ecosystem services. In some cases a government acts as a buyer (Steed 2007) by collecting taxes and grants, sometimes with earmarked contributions, and channelling through service providers (Wunder 2007). How long the government can act on behalf of users depends on a continuation of budget allocations.

Intermediary

Intermediary is defined as any actor who facilitates and maintains the exchange flows of services and payments between sellers and buyers (Figure 7-5). The roles of intermediary are as service and information providers, mediators, arbitrators, representatives, developers of standards and bridge builders (Thuy et al. 2010). Moreover, an intermediary is established in order to deal with transaction costs associated with PES programmes, especially when there are plenty of small landholders producing nonpoint source pollution (Jack et al. 2008). Transaction costs of PES typically include: 1) technical work to define links between the ecosystem and the services; 2) establishment of organisations to manage, monitor and support a programme; 3) establishment of property rights; and 4) monitoring the compliance (Kemkes et al. 2010). The distribution of small- and medium-scale farmers is scattered along the Ping river. This suggests that an intermediary is needed to generate collective action to link sellers and buyers.

The meta-analysis in chapter 2 revealed that there are many forms of intermediary, such as government agencies, NGOs, trust funds, communities, and the private sector. Each intermediary has its own advantages and disadvantages in the development and management of PES programmes (Thuy et al. 2010; Corbera et al. 2009). For example, farmer organisation or community has the advantage in negotiating with service sellers who are mainly poor farmers. But, it has the least power amongst intermediaries because of inferior political status. Government, on the other hand, is seen as the most powerful intermediary because of its highly centralised institution. However, the major disadvantage emerges from this centralised power as PES programmes may not reflect the need of service sellers and buyers.

The experience of PES programme in developing countries (i.e. Vietnam) suggested that some intermediaries may perform to support their interests, such as commercial and political missions (Thuy et al. 2010). As such, they are not neutral and may not work on the basis of benefits for either service sellers or buyers. Moss (2009) argued that the positive impacts of intermediaries depend on their international and local identities, relationships, capacity and adaptation to local situations. Further discussion focuses on the need to consider a combination of local organisations and government authorities to facilitate PES programmes (Thuy et al. 2010). This poses a challenge on an institutional interplay, which is a concept concerning the effectiveness of outcome regarding interactions between institutions (Young 2002). Moss (2004) recommended that, at the river basin scale, a negotiation amongst stakeholders and a creation of new partnership are required to efficiently manage water resource.

Practically, some water resource management programmes are based on considerations towards stakeholder interplay and participatory approach. These initiatives are characterisied by a catchment partnership and aim to promote collaborative resource management, to construct groups to do joint work and to build trust. Catchment partnership is needed because there always is a policy gap between water management planning (i.e. standards of water quality and quantity set by government authorities) and land-use management (i.e. conventional farming). Catchment partnership is seen in developed world; for example, the Dee catchment partnership (Dee Catchment Partnership 2009) and the Tay area management plan (SEPA 2008) in Scotland, and the Moreton Bay and Catchment in Australia (GWP Toolbox 2008). These partnerships normally involve a wide range of organisations, agencies and individuals, and work on a voluntary basis. Overall, they work as a network to establish a shared and long-term institution to support water resource management at the river basin scale, and to ensure that all stakeholders benefit from improvement in water quality.

7.2.2.2 Legal framework

A legal framework is needed to facilitate the establishment of PES programme. Here, a discussion regarding legal framework for the implementation of PES is relevant to well-defined property rights, and existing laws and regulations.

Property rights

Well-defined property rights are a prerequisite to commitment to conservation practices (George et al. 2009). In the context of PES, property right is related to the characteristics of CPR and the spatial flow of ecosystem services. Fisher et al. (2009) pointed to a subtle difference between CPR and ecosystem services. They argued that CPRs are resources producing benefits to human, while ecosystem services are the processes of delivering such benefits. For example, water quality has a characteristic of CPR because it is rival and non-excludable, whereas the regulating services of good water quality can be delivered through farm land which is typically a private property. In this sense, policy does not focus on 'water regulation' management, rather it highlights farm management practices, which provide water regulation services.

Descriptive statistics in chapter 4 revealed that 83% of farmers were landowners, while the remaining were tenants. For a service flow of water quality where downstream beneficiaries pay upstream farmers for the adoption of certain practices, Vatn (2009) argued that a lack of secured land title increases uncertainty for service buyers. The tenants are challenged with which rights they must have to involve their lands in the PES programme. Huang and Upadhyaya (2007) studied the characteristics of PES programmes in Southeast Asia and found that user rights over the resources were sufficient to establish working PES programmes. Similarly, George et al. (2009) conducted a PES study in northern Thailand. They concluded that as long as user rights have been respected, and a strong trust has been developed between sellers and buyers, land title issued by the government is not necessary for the implementation of a PES programme.

Existing laws and regulations

Laws and regulations provide effective incentives for an investment in a PES programme. Examples of legal provisions to induce farmers to change their farm management practices, especially in input uses and production practices, are widely seen in the United States (Swinton et al. 2006). The literature review in chapter 1 showed that current legislation in Thailand, such as an effluent charge, subsidies, and a labelling scheme, is available to manage farm water pollution (Thomas 2006). Nonetheless, these laws do not mandate an engagement in PES. For the sustainability of PES programme, an appropriate legal framework must be established so as to set institutional arrangements, responsibilities, and eligibility requirement (Takoukam and Morita 2008). Thus, policymakers must consider whether the need is to modify the existing laws and regulations to support PES, or to launch a new legislation (Huang and Upadhyaya 2007).

7.2.3 Payment mechanism

In the context of payment, in particular the question of ‘who should pay whom’, a fundamental question is whether farmers should be considered as polluters or service providers. Hatfield-Dodds (2006) argued that equity principles, PPP and BPP, provide a framework to consider who should bear the costs in achieving environmental goals. For the most part, demand for ecosystem services from beneficiaries creates market (Landell-Mill and Porras 2002), thereby implicitly assigning property rights over agricultural land to farmers. PES aims to compensate farmers for increasing the amount of positive externality above and beyond what they would have done (Antle 2007). Accordingly, a PES programme works on the basis of BPP (Engel et al. 2008), suggesting that an action provides a benefit must be compensated for.

The following question is whether the transfered payment within PES programmes violates the PPP principle. For example, a perverse incentive can happen as farmers may use practices that degrade natural resources in order that they can participate in the PES programme. Salzman (2005) argued that this perverse incentive is unlikely unless the expected private benefits of poor land management exceed the costs of doing so. This is because worsening current land management practices for potential payments can cause a significant cost in long-term farm productivity. However, if policymakers suspect the existing of perverse incentive, an establishment of baseline for participation could reduce such perverse incentive (Antle 2007).

There are several forms of payment mechanism depending on the characteristics of the commodity, sellers and buyers. The review in chapter 2 also showed that the most prominent payment mechanism for watershed services in developing countries is a government-intermediary based transaction. As a collective entity, government pools funds from groups of buyers and channels through sellers, and this creates a monopsony situation because a government seemingly acts as a single buyer. This monopsony power is merely a market form where there is a dominant buyer and multiple sellers. As such, monopsony is not relevant to the enforcement of either payments or cross compliance measures. Rather, it involves in a PES programme as an approach to reduce transaction costs, thereby increasing the potential to establish the PES programme (Kemkes et al. 2010; Salzman 2005).

The success of some PES programmes was due to them being monopsony markets. For example, a case in USA where the New York water authority is a single buyer for water purification. It pays farmers in the Catskill and Croton watershed to undertake forestry BMPs (Salzman 2005; Landell-Mills and Porras 2002). The success of this scheme is from the fact that the buyer can control the quantities of service desired by the public and estimate the costs to obtain such a goal (Antle 2007). The monopsony power is not limited to only government, rather the purely private market can also act as a monopsony. An example is the Vittel company in France who pays 26 farmers for an adoption of agricultural BMPs. The success of this project is a trust-building and the development of a long-term participatory process between the buyer and sellers (Perrot-Maître 2006).

Another issues relating to the payment mechanism is a payment schedule. Pagiola et al. (2005) stated that an appropriate payment schedule must be carefully designed and considered with care. For example, some BMPs have high front loading payments in the very first year, while certain BMPs have an equal instalment over the length of the contract. The suitable amount must be paid at the right time in order to induce farmers' participation and protect perverse incentives, such as a mismanagement of fund.

Apart from the considerations mentioned above, another issue to be considered is the total amount paid to providers in exchange for certain services. Pagiola et al. (2005) suggested that the payment amount is typically between the minimum a service provider is willing to accept in changing their land management and the maximum a service buyer is willing to pay for improved ecosystem service. As a rule of thumb, a total amount paid for sellers should cover their private opportunity costs, and direct costs incurred in the adoption of new practices (Sarker et al. 2008a). However, some farmers may not be interested only in direct cash compensation. Asquith et al. (2008) argued that non-cash incentives can be more effective than cash payment because they are seen to increase farmers' welfare over the long term.

Here, the results from the farm cost analysis in chapter 3 can give an indication on when the payment should be made and how much it should be. On a related point, findings from the Q study in chapter 6 could suggest what the potential non-cash payments are. The results revealed a few factors, such as technical supports, a marketing campaign and other forms of in-kind payments as needed to increase farmer's participation. Acknowledging the existing of these requirements that may change farmers' behaviours, the government can design a more responsive policy focusing on factors that may promote behaviour changes.

7.3 Policy Implications

7.3.1 Prerequisite conditions for PES programmes

This section addresses the requirements to develop a PES programme in order to manage nonpoint source pollution and improve water quality in the Ping river basin. Table 7-2 outlines some specific conditions that are needed to design the PES programme. The first condition is the geographical boundary of the PES programme which is defined to be the Ping river basin. The second condition defines the commodity for the PES programme. As water quality is not traded in a market, the BMPs are used as a service proxy.

The third condition concerns the eligible stakeholders: sellers, buyers and an intermediary. Sellers are clearly defined as citrus farmers. Buyers include both users and non-users. Users are those who receive direct benefits from an improvement in in-stream water quality, such as fisherman, water treatment works and local tourists. On the other hand, non-users are people who may enjoy non-use values of improved water quality and can make up a significant portion of the demand for environmental improvement. An example is residents who do not receive direct benefits from policy changes but notice an improvement in their surroundings. To designate between users and non-users, it is useful to distinguish the political jurisdiction concerning an administrative area, and the economic jurisdiction incorporating all stakeholders who hold economic values for an environmental improvement (Bateman et al. 2006). Furthermore, policymakers must make sure that buyers are willing to pay for the additionality of ecosystem services. Otherwise, the government can paly a vital role as a collective buyer.

Table 7-2: Design of PES programme

***Project*:** Watershed protection services through the adoption of BMPs

Conditions		Descriptions
1	Location	The Ping river basin, northern Thailand
2	Ecosystem service Commodity	Water quality BMPs (a service proxy, such as soil analysis)
3	Potential sellers Potential buyers Intermediary	Citrus farmers, in particular small – to medium – scale farmers 1) Beneficiaries, including both users and non-users; or 2) State government 1) At the district level, the local government, such as TAOs*, could be an intermediary 2) At the national level, the government agency such as the PCD could act as an intermediary 3) Roles of catchment partnership should be considered
4	Payment mechanism	Government-based transaction: 1) Funding methods; for example, - For users, e.g. entrance fee for ecotourism services, or tax from ecotourism business - For non-users, e.g. charge on household water bill - For a collective buyer, e.g. fuel tax, international donors 2) To induce farmers' participation, the amount of payment should cover investment cost, annual maintenance cost and opportunity cost of land. The payment schedule must be stated at the enrollment. 3) Other in-kind payments, such as training must be considered

Notes: * TAO is a local government unit in Thailand. It forms the third administrative subdivision level below the district and province.

As both sellers and buyers are scattered along the river, an intermediary is needed to facilitate the PES programme. An intermediary should also responsible for monitoring compliance and enforcing conditionality of the PES programme. For a PES development in the Ping river basin three options are suggested. If transactions occur at the local level, a local government agency could serve as an intermediary. If transactions occur at the national level, such as when the government acts as a collective buyer, the state government agency should be an intermediary. Alternatively, a partnership can be established to bring together all stakeholders of the Ping river basin so as to understand the needs and impacts associated with different uses of the river basin and to achieve a sustainable development of PES programme.

The fourth condition determines contract types and payment levels. An intermediary-based transaction is suggested to control transactions and risks from an implementation of the PES programme. Sources of payment depend on who are the buyers. For example, if the government is a buyer, sources of funding may come from the national income such as fuel tax or international donors. The transfer payment should cover all costs incurred by farmers, and this payment should include both cash and in-kind payments.

These four conditions are needed for designing a PES programme. Among the four conditions, perhaps the biggest challenge when it comes to implementing PES programmes in developing countries is to define the effective demands for ecosystem services (Sakuyama 2006). This is because the difficulty in measuring and valuing the non-use values, and the low willingness to pay (WTP) from low- to middle-income buyers. However, this issue could be solved if a government intervenes and acts as either a collective buyer or a main intermediary to sustain a long-term demand for ecosystem services. The next challenge is how to create a supply of the services. There are other requirements that are also needed to make the PES programme works.

7.3.2 Conditioning supply responses

Water quality has a characteristic of CPR, but the provision of a water regulating service is done through farm land, which is often privately-owned. Therefore, policies are needed to encourage farmers to provide such service (Kemkes et al. 2010). Behavioural changes are likely to be successful if policies are tailored to remove farmers' concerns from the adoption of new conservation practices. Interventions to promote behavioural changes generally use informational strategies to change attitudes. To be effective, information provision should be combined with other strategies, such as rewards and increased ease to perform the target behaviour (Lucas et al. 2008). The following sections outline some necessary interventions to motivate small- to medium- scale farmers in the Ping river basin to participate in a PES programme.

7.3.2.1 What to do to start a PES programme

1. **A well-defined property right must be established**: farmers must approve that they have the right over farmland. This right could be either landowner right or user right. This property right is to secure the conditionality of ecosystem service (Cobera et al. 2009).

2. **Additionality and baseline of ecosystem services must be established**: to support their decision-makings, farmers may need to know how changes in their farm activities positively impact ecosystem services. A modelling, such as an ecological economic model, can assist an analysis of the supply of ecosystem services from agriculture. On the other hand, as a PES is a performance-based programme (Antle 2007), a credible estimate of additional flows of environmental benefits is also useful to build social trust and create demands from prospective buyers.

3. **Incentives other then direct cash payment should be considered**: the incentives should be designed to reduce perceived risks in the adoption of new technologies. Incentives could be in the forms of direct cash payment, technical assistance or in-kind transfer. For example, a demonstration project is a medium to transfer new innovation from research to farm. It can improve a rate and extent of technology transfer by providing examples and facilitating visible accomplishments.

4. **Consideration should be given to flexibility in enrolment**: a number of farmers stated that institutional barriers such as contract, regulatory procedures and environmental regulation deter adoption. Flexibility should be considered for enrolment options to meet individual needs, such as farmers in remote area.

5. **The objectives of BMP adoption must be made clear**: the principles and objectives of BMP adoption must be made clear between sellers, an intermediary and buyers. This is also related to the condition in which payments will be paid in exchange for a certain service.

7.3.2.2 What to do to sustain a programme

1. **Appropriate technology is needed to monitor the compliance with the policy**: as nonpoint source pollution is hard to control and monitor, an alternative is to establish a proxy for monitoring purpose. Policymakers may set criteria - whether to monitor output (e.g. amount of N and P loaded into water bodies), or to change agricultural inputs (e.g. fertiliser reduction), or to change land use (e.g. construction of terracing)
2. **Certified quality labels should be promoted amongst consumers**: the adoption of some BMPs may lower fruit quality, such as colour and appearance. The literature shows that in Thailand there is a potential market for eco-friendly products (Roitner-Schobesberger et al. 2008; Yiridoe et al. 2005). To gain a marketing advantage, consumers must be informed about detailed information of label background, such as production method. Information can be spread through mass media or discussion in a public forum. A marketing campaign might help to assuage concerns that farmers have about a market for their BMP products.
3. **The clear scientific message should be diffused to farmers**: George et al. (2009) and Wunder et al. (2005) argued that basic knowledge of the linkage between land use and watershed services is required to sustain an effective implementation of PES programmes. To increase the effectiveness of communication, a two-way communication between scientists and farmers is needed, and scientific data must be diffused to the broadest possible audiences.
4. **Intermediary is accountable and its roles must be clearly defined**: this is a case when an intermediary is needed to facilitate a programme.

7.4 Nonpoint Source Pollution Management: What can be learned from the Ping river basin case?

The development of environmental policies in Thailand is different from what has been done in Western countries. Rather than guided by demands from the general public, the emergence of pollution management policies in Thailand has increased in response to environmental conditionality linked to low interest loans from development agencies (Akihisa 2008; Boyle 1998). Thus, the policies are normally top-down initiatives by governments themselves. When the Enhancement and Conservation of National Environmental Quality Act of 1992 was enacted, environmental policies moved toward a more bottom-up approach. Local authorities are allowed to formulate their own environmental management plans, which must be approved by the National Environmental Board (NEB) (ONEP 2010; Enhancement and Conservation of National Environmental Quality Act 1992).

Impaired water quality from farm pollution is a location-specific problem. A decentralisation of public services may allow agri-environmental policies to be more tailored to local conditions. However, in Thailand, a reliance on paternalistic authority and bureaucratic institutions result in a bureaucratic hierarchy. This leaves local authorities little power to implement and regulate environmental policies. Further, the final decision for implementing environmental policies is made at the national level (i.e. the NEB), and farmers are often treated as a passive target. Because farmers are resource managers and they are the main actors who deliver changes, the lack of farmers' voices impedes the effectiveness of agri-environmental policies.

Accordingly, this thesis aims to understand the circumstances within which farmers operate and how they make choices. It sets this within the context of a potential MBI (PES), which can lessen the water pollution from farms to some extent. The thesis applied a case of nonpoint source pollution management in the Ping river basin, and suggested BMPs as voluntary transactions to manage and control pollution at the farm scale. To investigate a farmer's decision-making, this thesis introduced a social psychology theory, i.e. the TPB, and a psychology research method, i.e. Q-Methodology. Rather than being a stand-alone alternative to understand behaviour, the psychology theory was used as a complement to a human rationality embedded in neoclassical economics theory. The findings revealed that there were many factors affecting farmers' behaviours. These factors were not limited to only external factors, such as farm environment, but also included internal factors, such as perception and attitudes. Policy implications based on these findings must proceed with cares. Policymakers should bear in mind that samples in this thesis included only small- to medium- scale farmers. One may argue that policy intervention with large-scale farmers may have higher impact on the management of water pollution. Howver, large-scale farmers who deal with higher benefit levels may have different behavioural responses to BMPs. Thus, this leaves a room for future research.

Overall, this thesis contributes to an improvement of our understanding of environmental policy using methods from the emerging field of Ecological Economics. Ecological Economics expresses human behaviour in terms of unbounded rationality and uncertainty, and suggests that an alternative model of human behaviour should include endogenous preferences and other social contexts to understand individual choices (Gowdy and Erickson 2005; Spash and Hanley 1995). This thesis aligns with a concept central to Ecological Economics in that it incorporates social psychology theory to explore farmers' behaviours. The findings confirmed that sometimes farmers do not make decisions based on a profit maximisation, and policy recommendations to induce pro-environmental behaviours were suggested based on incentives other than monetary incentives.

Application of the results and recommended policies should proceed with caution. Psychology models are specifically designed to generalise behaviour and to predict aggregate outcomes, and policy changes will not affect farmers equally because farmers are influenced by various factors (Darnton et al. 2006). Though some constraints are prevailing in an application of psychology models to explain economic behaviours, an acknowledgement that behaviours are not solely governed by economic considerations (i.e. profit maximisation) could improve the effectiveness of agri-environmental policies to manage farm pollution in Thailand.

As for a direction to develop PES programmes in Thailand, this thesis is useful, in that it pays particular attention to a supply side of the PES programme by focusing on small- to medium- scale farmers. The analysis centres on factors and conditions under which farmers are likely to adopt BMPs. However, there is another aspect to be considered. Future work should look into the demand side of PES programmes. Key issues to be addressed are who the buyers are, and the degree to which buyers are willing and able to pay for services. For the first question, it is necessary to clarify if there is an existing private voluntary demand for the services, and how this demand be consolidated. Future work may also consider environmental regulations to create demand, and investigate the role of government to pool demand and, to some extent, to fund PES programmes.

For the second question, future study can apply a TEV concept to assess the overall economic value of ecosystem services. Valuation techniques, such as stated preference methods, could be applied to estimate WTP for non-traded environmental goods and services. Analysis may expand from the standard valuation model by examining WTP in a behavioural framework through the use of TPB. A few studies (for example: Spash et al. 2009; Bernath and Roschewitz 2008; Luzar and Cosse 1998) showed that TPB is conceptually consistent with the process of contingent valuation. For example, the TPB could be used to investigate the motive behind payments by treating WTP as a behavioural intention, which could be predicted by attitudes toward payments, subjective norms with respect to payments and perceived behavioural control over payments.

7.5 Limitations and Recommendations for Methodological Improvement

7.5.1 Endogenous determinants in a psychology model

TPB is an extension of a former TRA. To deal with behaviour over which people have incomplete volitional control, the TPB includes perceived behavioural control as another independent predictor of intentions (Ajzen and Fishbein 1980). The TPB assumes that behaviours are predicted by behavioural intentions, and these intentions are predicted by three cognitive predictors which are attitudes, subjective norms and perceived behavioural controls. The construct of the TPB postulates that these three cognitive predictors are conceptually independent (Montoya et al. 2000), and assumes that behavioural intentions are driven only by internal psychological constructs, while external variables are considered to influence intentions and behaviours through psychological predictors (Burton 2004; Conner et al. 2000; Ajzen and Fishbein 1980).

With these underlying assumptions, the main limitation of the TPB model lies in its mediator and moderator effects[19] (Baron and Kenny 1986). Hence, it is unlikely to avoid the problem of endogeneity when conducting a statistical analysis. For example, Lam (1999) found that the three internal predictors may have mutual mediating effects to each other; Yzer et al. (2004) found that other external predictors may relate to internal predictors; and Hagger et

[19] A moderator is a variable affecting the direction and/or strength of the relationship between an independent variable and a dependent variable. A mediator is a variable explaining the relationship between external physical event and internal psychological significance.

al. (2002) found that a moderating effect could influence a relationship between intentions and behaviours.

7.5.2 Generalisation of the adoption model

The question is how meaningful an adoption model will be if it is derived from one context and applied in a different one. A generalisation of the TPB results to other environments must be made with caution because the factors for intentions may be different. There are two issues that should be taken into account when making a generalisation. First, the Ping river basin is a notable source of water in northern Thailand, and thus farmers may be more inclined to support BMP programmes perceived to benefit them. Second, it should be noted that during their interviews, farmers were instructed to make decisions under the predefined condition termed as TACT. As such, there is a possibility that farmers' decisions are bounded by this condition. A generalisation of the results is possible if the study is applied to closely related behaviours, or if there is a 'fit' in attributes of the samples and treatments between cases. For example, there is a wide range of attributes commonly shared between the samples.

7.5.3 The incorporation of cost in the model

The adoption model described in this thesis is a first step to understand attitude-behaviour relationships in BMP uptake. Though cost is one factor that influences adoption of new technologies, it is not incorporated in the adoption model for two main reasons. First, BMPs in this thesis are considered in the context of PES. The underlying principle of PES is that costs incurred by farmers are covered by transfer payments from beneficiaries. As such, costs are not involved in an economic decision. Second, the main aim of this thesis is to explain a change in behaviour and how this change can be affected. In this sense, a psychology model is suitable to investigate economic behaviour.

It has been recognised that costs in monetary form could not be incorporated into the psychological-based adoption model because the underlying principles of the psychology and economic theories are different (Pieters 1989). An alternative to investigate the effect of cost in behavioural change is to include a cost-evaluation statement in a questionnaire (Pieters 1989). For example, 'I can easily afford to pay for any BMP measure'. This belief statement reflects the costs incurred by farmers, and it indicates whether the farmers like or dislike the outcome as a consequence of behavioural change. This was done in this thesis. Further, a benefit-evaluation statement was also included in a questionnaire (Annex 5). In other words, this thesis offers an evaluation of subjective costs and benefits, rather than investigating the actual costs and benefits involved the BMP implementation.

However, the incorporation of cost into the adoption model is an important step in the attempt to accurately predict adoption behaviours. Future study could look for another possible mechanism that would allow costs to be incorporated into the adoption model. To do this, it is necessary to apply a stated preference survey method, such as the contingent valuation, to capture farmers' preferences toward costs. There is also an important assumption that farmers will adopt BMPs if they receive an amount of money in return. In other words, willingness to accept (WTA) is used to represent changes in the expenditure level of the farmers in response to changes in the level of ecosystem services provided. Applicability of the TPB in a contingent valuation could be done by replacing behavioural intentions with WTA (Pouta and Rekola 2001), and farmers may be further asked to bid on financial assistance. In this way, WTA will be predicted by attitudes, subjective norms, and perceived behavioural controls. This WTA will improve the understanding of the payment level that farmers are willing to adopt a certain BMP.

7.5.4 The applicability of Q results

Q-Methodology is a research method tailored for an in-depth investigation. Two main limitations in the use of Q-Methodology are: i) a generalisation of Q results is limited; and ii) an explanation that particular characteristics in one discourse will be consistently defining variables is unlikely[20]. This is because the sample size is small, and it is not randomly selected. For the generalisation, one may increase the size of sample. But, this only increases costs for no purpose because a well-selected sample is adequate to define salient attitudes. For the explanation beyond current findings in the Q study, Danielson (2007) suggested three techniques to overcome this problem.

[20] For example, though 8 out of 10 participants, who loaded on discourse A, were downstream farmers. It is not right to conclude that discourse A were represented by downstream farmers, as there are also downstream farmers in other discourses.

The first technique is a scale creation. To do this, one high-ranked statement and one low-ranked statement are selected from each discourse. These statements will be randomly presented in the form of psychometric scales (i.e. 5-point likert scale) to former participants. The scores given by participants will be multiplied by the z-score of corresponding statements, and then summed up. These scores will be normalised by converting to T-scores. This technique allows an explanation based on the participants' demographics. For example, Brown (2002) used this technique and was able to draw a general conclusion that perspective D is strongly represented among women[21].

The second technique is a profile correlation. All distinguishing statements from the Q analysis will be presented in the form of likert scales to randomly selected participants. Then, a Spearman correlation is used to compute the correlation between each participant's scores and the ranking of those statements in each discourse. The explanation of the discourse is based on the correlation-based scales. Danielson (2007) used this technique and found that; for example, household size and income were not related to the discourses, discourse H was likely to be participants with high levels of education[22].

The third technique is a narrative evaluation. Statements that were highly loaded on each discourse will be summarised and written in a short description, and then presented to the former participants. Participants are asked a few questions on how much they agree with the narrative summarisation. An explanation is based on the final score that participants adhere to each discourse. Danielson (2007) used this technique and concluded that socio-demographic variables were sporadically related to agreement with the discourse[23]. Future study may consider applying these three techniques so as to enable researchers to match participants to each discourse. Hence, an explanation can be made based on a prevalence of statements among the participants and relationship to other variables.

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[21] A study of Americans' views of the Clinton-Lewinsky affair. Discourse A was labelled as 'Kenneth Starr', discourse B was 'Moderates', discourse C was 'Clinton defenders', and discourse D was 'Opaque'.

[22] A study of public views toward wildfire management among Sydney residents. Four discourses were: F) Traditionalists; G) Responsible residents; H) Expert authorities; and I) Green democrats.

[23] A study of public views toward wildfire management in New Jersey. Five discourses were: A) Responsible managers; B) Community planners; C) Populists; D) Accountable citizens; and E) Scientific environmentalists

7.6 Recommendations for Future Research: BMP Uptake within a Cost-Benefit Framework

The results from the behavioural studies gave evidence about potential human behaviours and their responses to BMP adoption. To be more specifically, the results presented who the potential BMP adopters are and why they adopt BMPs. Perrot-Maître (2006) suggested that understanding farmer' s choices and constraints offer a sustainable development rather than a short-term contract. However, only an understanding in the individual preference may not be enough for the effective policy. A technical aspect must be included when making policy for the management of water pollution. This aspect concerns with the understanding of how management practices affect ecosystem and the services provided. In other words, it is necessary to understand the effectiveness of BMPs in pollution control and how changes in policy affect the ecological production function of ecosystem. To do this, economists must work with ecologists and other natural scientists in order to integrate knowledge to do justice to the underlying bio-physical and socioeconomic complexities involved in the provision of ecosystem services (Figure 7-6) (Polasky 2008).

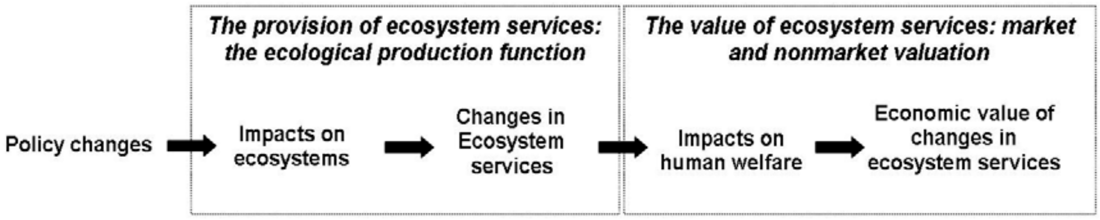

Figure 7-6: Impact pathway of policy change
Source: adapted from Defra (2007)

According to OECD (2010), two major evaluations widely used in the policy development process are ex-ante and ex-post evaluations. For a development of new policy, an ex-ante evaluation can provide information on whether this policy is economically profitable. Ex-ante assessments are based on a combination between economic and environmental models to evaluate economic responses to the proposed policy. However, ecosystem services have complex interactions within and between ecosystems from local to global scales. Furthermore, the characteristics and nature of nonpoint source pollution bring difficulties in the impact assessment. Firstly, accurate forecasts of environmental impacts may not be possible because farm discharge is stochastic and emissions cannot be directly measured. Secondly, the effectiveness of adopted practices is uncertain, especially in long term. Finally, identifying sources of water pollution is difficult as polluters could be both point and nonpoint sources. Accordingly, current research in the domain of Ecological Economics either conducts a field experiment (for example: Poudel et al. 2010; Deasy et al. 2009; Vinten et al. 2006) or applies a simulation model (for example: Yang et al. 2009; Daily and Matson, 2008; Vinten et al. 2008; Volk et al. 2008) to capture these complexities (i.e. to understand the impacts of pollution loads from farms, the delivery of pollution loads to watercourses). The field study is superior in its capability to reflect natural climatic variation. However, a simulation model is more useful in assessing long-term watershed-level BMP effects because the field study can monitor only at a particular site and period of time (Veith 2002).

As an illustration, the behavioural studies in this thesis revealed that the most preferred BMP amongst farmers was the soil analysis, which focuses on the reduction of fertiliser application. Policymakers may want to understand how the adoption of this BMP could lead to changes in water quality. It is recommended that an experiment should be done at the fields or an adoption of simulation model, such as the Material Flow Analysis (MFA) (Brunner and Rechberger 2004) may be useful to assess ecosystem services in bio-physical terms by quantifying the impacts of reduction fertiliser application rates on water quality. MFA is a tool to investigate the flows and stocks of a material-based system defined in the space and time. It can present flows and stocks of the system in a more transparent way and assess the relevant flows and stocks in quantifiable terms (Baccini and Brunner 1991). For example, a previous study by Schaffner (2007) applied MFA to simulate nutrient loads in the Thachin river basin in central Thailand. The basic model approach from her study can be transferred to the Ping river basin provided the parametre sets are adjusted to match with the regional differences.

Once the potential impacts of policy options on ecosystem services are identified, this needs to revert back to an economic valuation (Figure 7-6). Economic valuation refers to a process of monetisation of changes in environmental impacts as a result of a new policy (Pearce and Seccombe-Hett 2000). The economic and water quality impacts of agricultural BMPs at watershed scale in Thailand are poorly understood. To assess the economic and water quality impacts, an integrated framework is required. Consider Figure 7-6, an introduction of environmental policy induces changes in the reduction of pollution emission and improved water quality, and this quality improvement affects human welfare. This suggests that a water quality modelling, designed for tracing pollutants loaded into river, can serve as the basis for an economic analysis, such as CBA. In other words, results from the model can provide essential information to evaluate the potential of achieving water quality improvement through reducing farm pollution.

Water quality provides two broad classes of economic benefits which are withdrawal and in-stream benefits (Bingham et al. 2000). Withdrawal benefits include abstraction benefits for municipal water supply and domestic use, agricultural irrigation and livestock watering, and industry process. In-stream benefits include use and non-use benefits. In-stream use benefits are defined as benefits associated with direct human interaction with water in the river, such as swimming and boatable benefits; and aesthetic value of water quality, such as stream side property owners. In-stream non-use benefits are values accruing to individuals regardless of whether or not they have direct interaction with water. These are stewardship value, altruistic value, bequest value, and existence value[24].

To date, numerous economic valuation methods have been used to assign quantitative monetary values to environmental goods and services. Most of the literature has analysed human welfare changes within the framework of TEV (Hussain et al. 2010; Richardson and Loomis 2009; Moran and Dann 2008; Menegaki et al. 2007). Valuation techniques which are direct or stated preference, and indirect or revealed preference are applied to measure welfare changes in terms of WTP or WTA due to policy intervention (Pearce et al. 2006). For example, stated preference methods involve questioning survey respondents to determine their consumer surplus, whereas revealed preference methods use data from consumer market behaviour to estimate economic values. Alternatively, when limited time or funding precludes costly data collection and the development of new consumer surplus estimates, the method of benefit transfer (BT) can be used to tailor pre-existing consumer surplus estimates to fit new policy situations (Pearce et al. 2006; Boyle and Bergstrom 1992; Desvousges et al. 1992).

[24] A stewardship value is a belief that humans are responsible for maintaining the level of water quality though there is no withdrawal or in-stream use benefit. Altruistic value is the enjoyment people gain from knowing that the others enjoy use values. Bequest value is a benefit from ensuring that environmental goods are preserved for the future. Existence value represents enjoyment people perceive from knowing that some level of environmental quality exists.

With BT application, benefit estimates from existing direct or indirect valuation case studies, or study sites, are spatially and temporally transferred to a new case study, or policy site. There are four types of BT approaches, which are benefit estimate transfer (Boyle and Bergstrom 1992), benefit function transfer (Kirchhoff et al. 1997), meta-analysis (Bergstrom and Taylor 2006; Smith and Pattanayak 2002), and preference calibration (Pattanayak et al. 2007). Benefit estimate transfer is the simplest method, where economic value on a per-unit basis is taken from study site(s) to a policy site. The function transfer relates an individual's willingness to pay to a set of individual and site characteristics. Characteristics from the policy site are substituted into the model from the study site to tailor benefit estimates for the policy site. In the meta-analysis, WTP benefit estimates from numerous similar study site(s) serve as the dependent variable in regression analysis, and characteristics of the study site(s), such as water quality serve as the independent variables. BT in the context of preference calibration simply means using the estimates from multiple methods to establish numerical values for parameters that shape a specified preference function (i.e. an indirect utility function) for the policy site. Preference calibration was developed to avoid double counting of benefits by conducting transfer in a manner explicitly consistent with utility theory (Smith et al. 2002).

In terms of transferability of BT values there is a particular concern about transfer of values from developed countries to developing countries. It is preferable to transfer benefits from a study site located close to a policy site as the socio-economic characteristics and cultural factors between two sites could be comparable (Ready and Navrud 2006; Krupnick 1993). However, the valuation of water quality improvement has been largely conducted in developed countries. Therefore, it is inevitable that BT involves transfer of a benefit estimate from high-income countries to low-income countries. Given that users between two sites have identical underlying preferences towards ecological services and WTP represents willingness to pay for an improvement of environmental goods and services in country (*i*) and time (*t*), Pattanayak et al. (2002) suggested the use of a conversion index to reflect the relevant change in value across time and space. Further, empirical studies also reveal the validity of international BT, provided the adjusted value transfer is used (Ready and Navrud 2006; Brouwer 2000; Bergstrom and De Civita 1999; Kirchhoff et al. 1997; Chestnut et al. 1997; Alberini et al. 1997).

Another caveat to BT relates to the superiority of benefit function transfer relative to unit transfer. A number of studies have performed statistical convergent validity tests and value surface tests on BT values derived from both unit and function transfer approaches (Muthke and Holm-Mueller 2004; Barton 2002; Loomis et al. 1995). A major implication of these tests is that the degree of accuracy of BT value depends on how the results will be used (Bergstrom and De Civita 1999). The minimum degree of accuracy necessary is related to policy context such as policy goal and objective (Ready et al. 2004), and the cost of making a wrong decision based on the results of the BT (Filion et al. 2002) (Figure 7-7). In other words, when applying a BT study a trade-off must be made amongst the increased cost and delay associated with the new study, the reliability of results from a primary study (i.e. Contingent Valuation Method), and the expected loss related to making an incorrect decision. For example, Figure 7-7 shows that using BT to demonstrate how valuation can be used in an environmental assessment would require a middle level of accuracy, whereas a valuation of extremely scarce environmental attributes such as endangered species requires a primary study as the cost of making wrong decision may be high.

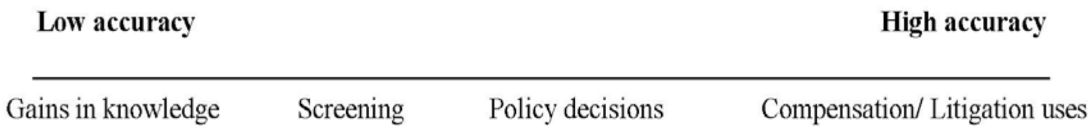

Figure 7-7: Continuum of accuracy for BT analysis
Source: Filion et al. (2002)

To define prospective beneficiaries from policy changes, the conceptual framework of ecosystem services proposed by Millennium Ecosystem Assessment (2005) (Figure 7-8) offers a link to taking an economic valuation. For example, one of the most important services of an agricultural field is the natural purification of water (Swinton et al. 2007). An improper use of agricultural land threatens the existence of regulating and supporting ecosystem services (i.e. excessive uses of fertiliser in farm may affect the bioremediation of waste through dilution and oxidation process, and impair water quality) (Ruhl 2008). The adoption of BMP, such as reduction in fertiliser uses, results in improved water quality. A clear and well-defined link between ecosystem services and human-wellbeing can help avoid the problem of double counting of benefits because only the final services (i.e. benefits to human) are taken into the decision process (i.e. CBA) (Smith 2006).

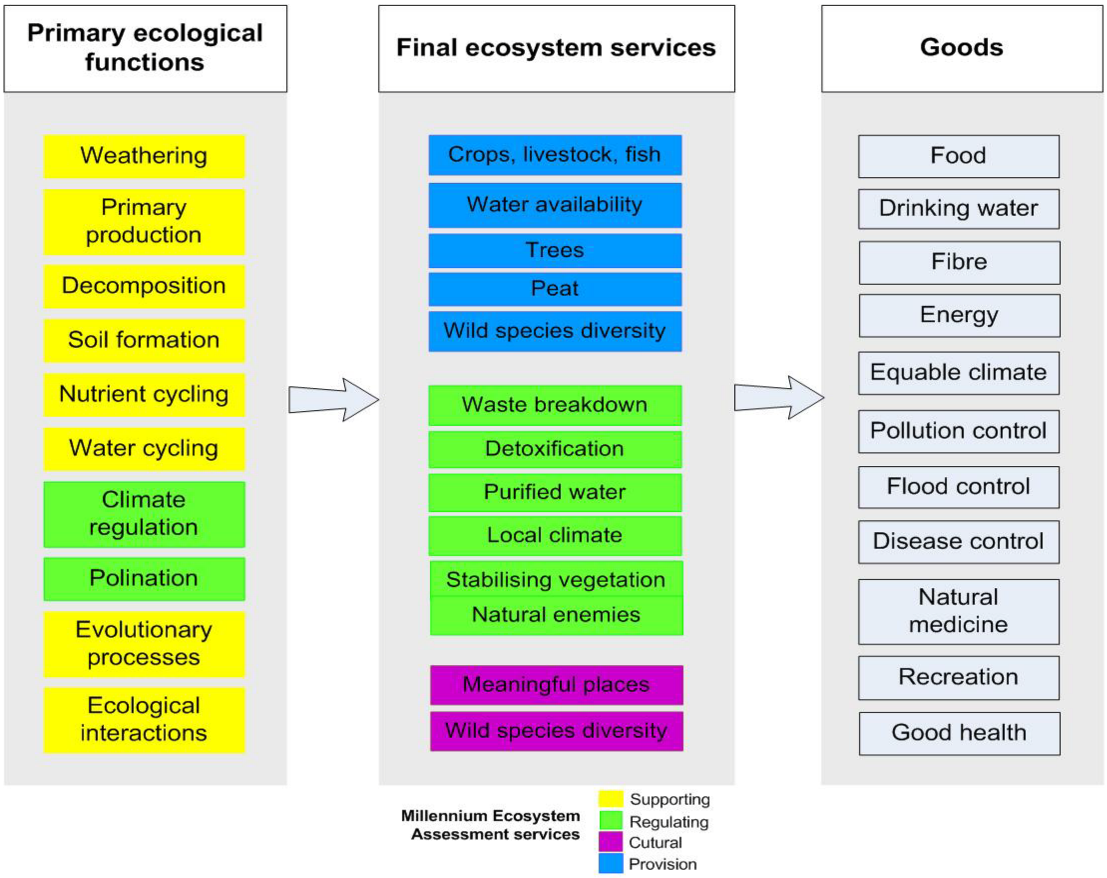

Figure 7-8: From ecosystem processes and final services to economic goods
Source: adapted from Bateman et al. (2010)

On a related issue, Kemkes et al. (2010) argue that an understanding of the spatial distribution of ecosystem services is the key to identify potential beneficiaries. Spatial distribution defines the directional flow of the service and its geographical extent to which benefits accrue. In terms of water quality supply, the spatial distribution is known to be a benefit accruing downstream at a regional watershed scale (Costanza 2008). The quantification of impacts based on the conceptual framework of ecosystem services and spatial scale allows to systematically defining the groups of beneficiary being affected by changes in policies (and ecosystem services as a consequence).

Bateman et al. (2006) differentiated two broad types of potential beneficiary: users and non-users. Users will hold use and option-use values and may hold non-use values, while non-users may hold option and non-use values. One of the contested issues is that users and non-users may hold different preferences towards a site; therefore, they may have a different

WTP value. For example, users may hold higher WTP values than non-users regarding experiences with the site. On the other hand, there may be a cultural identity attached to the site and non-users express their higher non-use values (Hanley et al. 2003). Further discussion focuses on the issues such as: How to divide between users and non-users? and How many of them will benefit? Though it is complex to quantify the number of non-users benefiting from a policy change, it is necessary to estimate aggregate benefits based on a per-person benefit from both user types (Hanley et al. 2003). Furthermore, aggregate benefits should be considered by taking into account the conceptual framework of ecosystem services and a spatial distribution of ecosystem services. This makes it easier to consider the distributional impacts of the policy, and the benefit distribution could further suggest who should pay for the project and how much (Jenkins 1999).

The economic efficiency of any new policy must be evaluated based on both positive and negative aspects. In the context of water quality, cost estimates for achieving a given reduction in pollutant inputs or of achieving target pollutant concentration in receiving waters, must be considered. In general, cost assessment is straightforward and can be determined by placing economic values on the amount of resources required to plan, implement, and complete a programme. Pearce et al. (2006) suggested that costs simply mean environmental losses or damages done by a project, and the sum of compliance and regulatory costs. Provided that all relevant economic values are taken into account, these values should be included in a CBA. To conduct a CBA, the Asian Development Bank (ADB 1999) suggested that the with project situation (i.e. with the BMP adoption) should be compared with the without project situation (i.e. current farming practices).

To make a comparison, CBA is a welfare-theoretical method to evaluate net social benefits of project, programme, or policy. The advantages of CBA are that it defines gainers and losers in spatial and temporal dimensions, and can supplement scientific and technical information with economic information that may help decision makers (Pearce et al. 2006). CBA has been used to inform policy decision-making; for example, the net positive benefit suggests that a project is viable and worthwhile. In the light of CBA, it is also important to conduct a sensitivity analysis (SA). SA indicates how the CBA outcome of a project reacts to changes in crucial input variables. The crudest approach is to increase or decrease gross costs and benefits (Vaughan et al. 2000). A particular attention is to the investigation of cost variation as past experience suggested that cost can be seriously understated (Pearce et al.

2006). Besides the uncertainties in net benefits, Just et al. (2004) argued that a choice of discount rate may contribute to a substantial difference in CBA outcome, and SA should examine the net benefits under the range of plausible discount rates rather than relying on a single rate.

CBA can benefit from the input of a water quality model. Eisen-Hecht and Kramer (2002) agree that a simulation model allows for a more reliable prediction whether the proposed management activity would be effective in achieving its goal. A model also gives flexibility to compare costs and benefits for different management scenarios. In additional, the integration of economic valuation and ecosystem services could contribute to policy decisions, for at least in five domains (Fisher et al. 2008). Firstly, results have been passed to relevant agencies. Secondly, results have been presented to intermediaries who are able to facilitate a PES programme. Thirdly, CBA is the first step to gain interests from policymakers. Fourthly, results have been used for a policy debate. Finally, CBA is a major stimulus for the launch of many conservation programmes and this is the greatest influence on the policy process.

Agricultural land has long been perceived to supply ecosystem services, such as water purification (Ruhl 2008) (see for example: the Catskill watershed case in USA and the Vittel company in France (Rollett et al. 2008)). Farmers' management decisions both affect and are affected by the biophysical and economic settings in which they operate, while land-use management influences supply of ecosystem services (Foley et al. 2005). In a development of PES programme, it is necessary to explicitly define how land-use management could contribute to ecosystem service provision. As long as changed land management practice continues to be the mechanism on which transfer payments are based, the knowledge of how new management practices affect environmental outcomes is needed to confirm that the potential positive impacts from adoption could occur.

Under the concept of Ecological Economics, natural and social capitals become the limiting factors in economy growth (Costanza 2009a; Costanza 2009b). Thus, ecological processes should be taken into account before conducting a valuation exercise. This is a first step to address ecological sustainability in a rigorous way in environmental policy assessments. An integration of ecology and economics in a valuation of ecosystem services improves understanding in an additionality of new farming practices. This additionality is used as an indicator offering a link to the estimate of economic benefits, thereby improving decision making by clarly illustrating both bio-physical and economic consequences of policy options (Iovanna and Newbold 2007). It is also recommended that policy should be simple enough to be implemented yet sophisticated enough to do justice to the underlying bio-physical and economics complexities involved (Polasky 2008).

To sunmmarise, the ultimate aim of this study was to make policy recommendations in the development of PES programme in Thailand. PES is a new paradigm of conditional conservation potentially addressing the management of diffuse water pollution from agriculture. In this study, a suit of BMPs was proposed as tradable services in a PES programme, and psychological principles were used to examine factors and beliefs underlying intentions to adopt BMPs. From a policy perspective, the study to identify key cognitive factors influencing adoptions is important as long as diffuse water pollution is one of primary environmental concerns.

However, there are at least two main limitations that need to be acknowledged regarding the present study. The first limitation concerns the employed methodologies, such as the generalisation of the adoption model and the applicability of the results. The second limitation is a lack of technical aspects of BMPs in particular on the role of bio-physical model in an estimation of BMP effectiveness. These limitations were crucially addressed and recommendations for future research were also discussed. It appears clearly from the study that BMP is a potential tool for water conservation in Thailand. Lessons learned from this study suggested that future research should focus on a combination of behavioural study, economic valuation, and integrated model in order to provide insights into sustainable and welfare-optimising resource magagement and policy.

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Annex 1: Current Payment for Watershed Services Programmes

Project area	Country	Market driver	Commodity	Payment mechanism	References
Bermajo river basin	Argentina and Bolivia	G & Mul Org	Designed contract	Pooled- transaction/ OTC-user fee	Organization of American States (2005)
Hunter river	Australia	G	Credit scheme/ emission trade	G intermediary-based/ clearing house/ auction	Environmental Protection Authority (2003)
Liverpool Plains	Australia	G & NGOs	Credit scheme	Auction	Liverpool Plains Land Management Committee and WWF (2005)
Bubble licensing	Australia	G	Emission trade	G intermediary-based	Kraemer et al. (2003)
Macquarie river	Australia	G & C	Credit scheme	G intermediary-based/ pooled-transaction	Perrot-Maître and Davis (2001)
NSW/ dry land salinity	Australia	G	Emission trade	Auction	Landell-Mills and Porras (2002); Perrot-Maître and Davis (2001)
Piracicaba river	Brazil	G	Right re-allocation	G intermediary-based	UN-HABITAT (2006)
State of Parana	Brazil	G	Right re-allocation	Redistribution mechanism	Mayrand and Paquin (2004); Perrot-Maître and Davis (2001); Monzoni (2001)
Ribeira do Iguape	Brazil	G	Right re-allocation	G intermediary-based	Monzoni (2001)
Minas Gerais	Brazil	G	Right re-allocation	G intermediary-based	Mayrand and Paquin (2004); Monzoni (2001)
Paraiba do Sul river	Brazil	G	Right re-allocation	G intermediary-based	Diz and Soeftestad (2004)
RSP	Canada	C & G	Designed contract	G intermediary-based	United Nations (2005)
The Greencover	Canada	G	Designed contract/ scientific proof	G intermediary-based	Agriculture and Agri-Food Canada (2007)
Beijing, Hebei, Shanxi	China	G	Right re-allocation	Internal trading	MWR (2003)
Jianxi province	China	G	Right re-allocation	Direct negotiation/ G intermediary-based/ OTC-user fee	Liu (2002)
Jinhua river	China	G	Right re-allocation	Direct negotiation/ G intermediary-based	Liu (2005)
Qujiang	China	G	Right re-allocation	G intermediary-based	Bautista (2003)
Wuhua	China	G	Land tenure transfer	G intermediary-based	Deyi (1996)

Project area	Country	Market driver	Commodity	Payment mechanism	References
Valle del Cauca	Columbia	C & G	Right re-allocation	C intermediary-based/pooled-transaction/ OTC-user fee	Perrot-Maître and Davis (2001); Echavarria (2000); Echavarria and Lochman (1998)
RACs	Columbia	G	Right re-allocation	G intermediary-based	Rodriguez Becerra and Ponce de Leon (1999)
Energia Global	Costa Rica	G	Designed contract	G & NGOs intermediary-based/ pooled-transaction/ OTC-user fee	Redondo-Brenes and Welsh (2006); Russo and Candela (2006)
Platanar	Costa Rica	P	Designed contract	G & NGOs intermediary-based/ pooled-transaction/ OTC-user fee	Redondo-Brenes and Welsh (2006); Russo and Candela (2006)
Monteverda	Costa Rica	G	Right re-allocation	G intermediary-based/ pooled-transaction	Hope et al. (2007); Russo and Candela (2006); Perrot-Maître and Davis (2001)
Heredia	Costa Rica	G	Right re-allocation	Trust fund intermediary-based	Kosoy et al. (2007); Redondo-Brenes and Welsh (2006)
Del Oro	Costa Rica	P	Eco-labelling	Direct negotiation	Porras et al. (2006)
FONAFIFO	Costa Rica	G & NGOs & P	Right re-allocation/ Eco-labelling	G & NGOs intermediary-based/ OTC-user fee	Redondo-Brenes and Welsh (2006); Russo and Candela (2006); Mayrand and Paquin (2004)
Pimampiro	Ecuador	C & NGOs	Right re-allocation	NGOs intermediary-based	Echavarria et al. (2003)
Cuenca city	Ecuador	G	Right re-allocation	G & C intermediary-based/ OTC-user fee	Echavarria et al. (2003)
Yanuncay	Ecuador	C	Designed contract	Direct negotiation/ G intermediary-based	Echavarria et al. (2003)
Quito	Ecuador	G	Designed contract/ right re-allocation	Trust fund intermediary-based/ pooled transaction/ OTC-user fee	Echavarria (2002)
AEMs	Estonia	G	Designed contract	G intermediary-based	United Nations (2005)
AEMs	EU	G	Designed contract	G intermediary-based	United Nations (2005)
Nestle water	France	P	Designed contract	Direct negotiation	Déprés and Grolleau (2005)
Auxerre	France	P	Designed contract	Direct negotiation	Déprés and Grolleau (2005)

Project area	Country	Market driver	Commodity	Payment mechanism	References
Mangfall valley	Germany	P	Designed contract	Direct negotiation	Déprés and Grolleau (2005)
Sierra de las Minas	Guatemala	G	Designed contract	Pooled-transaction	Méndez et al. (2004)
El Escondido	Honduras	G	Extra payment	G intermediary-based	Mayrand and Paquin (2004)
Jesus de Otoro	Honduras	C & NGOs	Designed contract/ right re-allocation	NGOs intermediary-based	Kosoy et al. (2007); Kosoy et al. (2005)
Himachal Pradesh	India	G	Designed contract	G intermediary-based/ internal trading	Sengupta et al. (2003)
Bhoj	India	G	Designed contract/ eco-labelling	G intermediary-based	Winrock International India (2005)
Sukhomajari	India	G	Water right trade	G intermediary-based/ pooled-transaction/OTC-user fee	Sengupta et al. (2003)
Hanyana	India	C	Water right trade	Direct negotiation	Sengupta et al. (2003)
Maharashtra	India	C	Water right trade	C intermediary-based	Apte (2001)
Madhya Pradesh	India	G	Right re-allocation	G intermediary-based	Winrock International India (2005)
Segara river	Indonesia	G	Right re-allocation	Direct negotiation/ G intermediary-based	Munawir et al.(2003)
Brantas river	Indonesia	G	Right re-allocation	G intermediary-based	Munawir and Vermeulen (2007)
Cidanau river	Indonesia	G	Designed contract	G intermediary-based	Munawir et al.(2003)
REPS	Ireland	G	Designed contract	G intermediary-based	United Nations (2005)
Coatepec	Mexico	G	Extra payment	G intermediary-based	Mayrand and Paquin (2004)
CONAFOR	Mexico	G	Designed contract	Trust fund intermediary-based	Muñoz-Piña et al. (2005)
San Pedro del Norte	Nicaragua	G	Designed contract	G intermediary-based	Sustainable Agriculture and Rural Development (2005)
Maasin	The Philippines	G	Right re-allocation	G intermediary-based	Arocena-Francisco and Salas (2004)
Makiling forest reserve	The Philippines	G	Right re-allocation	Trust fund intermediary-based/ OTC-user fee	Perrot-Maître and Davis (2001)
WfW	RSA	G	Right re-allocation	G intermediary-based	King et al. (2003)
Agriculture Charge	RSA	G	Right re-allocation	G intermediary-based	DWAF (2003b)

Project area	Country	Market driver	Commodity	Payment mechanism	References
SFRA	RSA	G	Emission trade	OTC-user fee	DWAF (2003a)
Industry Charge	RSA	G	Right re-allocation	G intermediary-based	DWAF (2003c)
Phalaborwa barrage	RSA	G & NGOs	Designed contract	Pooled transaction	CSIR and IIED (2005)
Intensive farming	Switzerland	G	Designed contract	G intermediary-based	United Nations (2005)
Portland, Oregon	USA	G	Designed contract/ land tenure transfer	G intermediary-based/ OTC user fee	Johnson et al. (2002)
Impaired water body	USA	G	Emission trade	G intermediary-based	Federal Water Pollution Control Act (2002)
New York	USA	G	Designed contract/ land tenure transfer	Trust fund & NGOs intermediary-based	Perrot-Maître and Davis (2001)
CRP	USA	G	Designed contract	G intermediary-based	Perrot-Maître and Davis (2001)
Lower Boise river	USA	G	Credit scheme	Clearing house	Perrot-Maître and Davis (2001)
Nutrient trading	USA	G	Designed contract/ emission trade	G intermediary-based/ clearing house	Ross & Associates Environmental Consulting (2000)
Salmon-safe	USA	P	Eco-labelling	Retail based	Smith et al. (2006)
Ecolotree	USA	P	Scientific proof	OTC-user fee	Ecolotree (2004)
Tar-Pamilco basin	USA	G	Emission trade	Clearing house	Environomics (1999)
Great Miami river	USA	G	Designed contract/ credit scheme	G intermediary-based	Miami Conservancy District (2005)
National programme	Vietnam	G	Designed contract/ land tenure transfer	G intermediary-based	Wunder et al. (2005); Sikor (2001)

Notes:

1) G = Government agency; P = Private agency; C = Community; Mul Org = Multilateral organisation ; NGOs = Non-government organisations
2) OTC = Over the counter trade

Annex 2: Cost worksheet

T1 Ditch management (Cost per Rai)

No.	Description	Q'ty	Unit	Material	Labour	Total
1	***Earthwork of 1 ditch per rai (2.0T, 0.5B x 1.0)***	***50***	***cu.m.***	***-***	***45.00***	***2,250.00***
1.1	Planning of Irrigation Routes	10%				225.00
1.2	Removing unwanted materials and trees from ditch lines	30%				675.00
1.3	Excavation	60%				1,350.00
2	***Annual maintenance: Slope adjustment***	***60***	***sq.m.***	***-***	***5.00***	***300.00***
2.1	Removing unwanted plant	50%				150.00
2.2	Ditch Maintenance	50%				150.00

T2 Herbicide Application (Cost per Rai)

No.	Description	Q'ty	Unit	Material	Labour	Total
1	***Normal shadow area of citrus 3m x 3m***	***587.8***	***sq.m.***	***-***	***1.00***	***587.76***
1.1	Removing unwanted plants	100%				587.76
2	***Annual soil maintenance***	***587.8***	***sq.m.***	***-***	***0.50***	***293.88***
2.1	Removing new unwanted plants	100%				293.88

T3 Pesticide application (Cost per Rai)

No.	Description	Q'ty	Unit	Material	Labour	Total
1	***Standard Equipment***	***0.1***	***Man/Rai***		***-***	***1,360.00***
1.1	Spraying Equipment	1.0	set	550.00	-	550.00
1.2	Gloves	1.0	set	30.00	-	30.00
1.3	Glasses	1.0	set	180.00	-	180.00
1.4	Spraying suit	1.0	set	450.00	-	450.00
1.5	Helmet	1.0	set	150.00	-	150.00
2	***Annual maintenance***		times			
2.1	Sprayer equipment calibration					time consuming
2.2	Record keeping					time consuming

T4 Nutrient management (Cost per Rai)

No.	Description	Q'ty	Unit	Material	Labour	Total
1	***Soil analysis***	***0.1***	***Man/Rai***			***3,300.00***
1.1	Organic matter test	1.0	sample	1,000.00		1,000.00
1.2	Organic fertiliser	920.0	kg	2.50		2,300.00
2	***Annual maintenance***	1	times			***1,650.00***
2.1	Organic matter test	1.0	sample	150.00		150.00
2.2	Organic fertiliser	600.0	kg	2.50		1,500.00

T5 Vegetative Cover (Cost per Rai)

No.	Description	Q'ty	Unit	Material	Labour	Total
1	***First-time grass growing***	***800.0***	***sq.m.***	***0.50***	***1.00***	***1,200.00***
1.1	Seeding/Planting	50%				600.00
1.2	Plowing (tillage)	50%				600.00
2	***Annual maintenance: Grass field maintenance***	***1600.0***	***sq.m.***	***-***	***0.25***	***400.00***
2.1	Maintaining vegetative field	80%				320.00
2.2	Replanting some destroyed area	20%				80.00

T6 Mulching (Cost per Rai)

No.	Description	Q'ty	Unit	Material	Labour	Total
1	***First-time mulching (Buy-in some straw etc.)***	***587.8***	***sq.m.***	***0.50***	***1.00***	***881.63***
1.1	Procuring straw/dried plants	50%				440.82
1.2	Improving soil surface	25%				220.41
1.3	Paving	25%				220.41
2	***Annual maintenance: Field maintenance***	***293.9***	***sq.m.***	***-***	***1.00***	***293.88***
2.1	Remulching (if necessary)	50%				146.94
2.2	Paving	50%				146.94

T7 Vegetative Buffer Strip (Cost in Lumpsum) for distance 15 m

No.	Description	Q'ty	Unit	Material	Labour	Total
1	***First-time planting (Buffer width 6m)***	***90.0***	***sq.m.***	***2.50***	***10.00***	***1,125.00***
	- including clearing, tilage, and planting					
1.1	Preparing soil surface	30%				337.50
1.2	Procuring seeds/plants	5%				56.25
1.3	Planting	65%				731.25
2	***Field maintenance***	***90.0***	***sq.m.***	***-***	***1.00***	***90.00***
2.1	Vetiver trimming	70%				63.00
2.2	Replanting some destroyed area	30%				27.00

T8 Grassed Waterway (Cost per Rai)

No.	Description	Q'ty	Unit	Material	Labour	Total
1	***Earthwork of 1 ditch per rai (2.0T, 0.5B x 0.5)***					***1,365.00***
1.1	Preparing waterway routes	25%				341.25
1.2	Excavation	50%				682.50
1.3	Seeding/Planting	25%				341.25
2	***Annual maintenance***	***80***	***sq.m.***	***-***	***1.50***	***120.00***
2.1	Maintaining grass	40%				48.00
2.2	Maintaining ditch	60%				72.00

T9 On-site retention pond (Cost in Lumpsum) for citrus area 1 rai

No.	Description	Q'ty	Unit	Material	Labour	Total
1	***First-time excavation (slope 1:1, depth 3 m.)***	12.65	m			***15,155.54***
1.1	Preparing pond area	25%				4,211.85
1.2	Excavation	50%				8,423.69
1.3	Vetiver planting	25%				2,520.00
2	***Annual field maintenance***	***306.3***	***cu.m.***	***-***	***2.50***	***765.79***
2.1	Vetiver trimming	70%				63.00
2.2	Replanting some destroyed area	30%				27.00

T10 Terracing (Typical Soil Terracing for Orchard Bench Terrace)

No.	Description	Q'ty	Unit	Material	Labour	Total
1	***Earthwork for slope 1:***	***25***				***1,846.53***
1.1	Design&Preparing slope area	15%				276.98
1.2	Excavation + Backfill	50%				923.27
1.3	Planting of vegetative cover in between citrus lines	35%				646.29
2	***Annual maintenance***					***935.00***
2.1	Maintaining soil surface for slope&terrace area	65%				260.00
2.2	Maintaining planted area	35%				675.00

T11 Permanent mix load and wash-down site

Option I (farm size < 10 rais)

No.	Description	Q'ty	Unit	Material	Labour	Total
1	***Standard Building size 2.5m x 2.5m***					
1.1	Excavation+Backfill	3.8	cu.m.	-	55.00	206.25
1.2	RC. Slab	1.9	cu.m.	750.00	350.00	2,062.50
1.3	Block wall	24.0	sq.m.	140.00	75.00	5,160.00
1.4	Roofing	10.8	sq.m.	180.00	150.00	3,564.00
1.5	Accessories (door, window, etc.)	1.0	lumpsum	2,500.00	500.00	3,000.00
1.6	Electrical and Mechanical works	1.0	lumpsum	5000.00	2500.00	7,500.00
1.7	Chemical Storage Tank	1.0	lumpsum	7500.00	1500.00	9,000.00
1.8	Water Pump	1.0	lumpsum	3500.00	500.00	4,000.00
1.9	Miscellaneous 10%	1.0	lumpsum	-	-	3,449.28
	Sub-Total			19,570.00	5,630.00	37,942.03
2	***Standard deck 5m x 5m W/ deck 5m x 5m***					
	Excavation+Backfill	12.5	cu.m.	-	55.00	687.50
	RC. Slab	7.5	cu.m.	750.00	350.00	8,250.00
	Sub-Total			750.00	405.00	8,937.50
2.1	Design&Preparing site	5%				446.88
2.2	Building + Pre-Load Area	50%				4,468.75
2.3	Equipment	20%				1,787.50
2.4	Labour	20%				1,787.50
2.5	Construction tools	5%				446.88
3	***Yearly maintenance***	***1***	***times***			

	Miscellaneous (5% of building cost)	1.0	lumpsum			2,343.98
3.1	Maintaining site condition	100%				2,343.98

Option II (farm size 10.01 - 50 rais)

No.	Description	Q'ty	Unit	Material	Labour	Total
1	***Standard Building size 4m x 4m***					
1.1	Excavation+Backfill	9.6	cu.m.	-	55.00	528.00
1.2	RC. Slab	4.8	cu.m.	750.00	350.00	5,280.00
1.3	Block wall	38.4	sq.m.	140.00	75.00	8,256.00
1.4	Roofing	19.2	sq.m.	180.00	150.00	6,336.00
1.5	Accessories (door, window, etc.)	1.0	lumpsum	5,000.00	500.00	5,500.00
1.6	Electrical and Mechanical works	1.0	lumpsum	7500.00	2500.00	10,000.00
1.7	Chemical Storage Tank	1.0	lumpsum	7500.00	1500.00	9,000.00
1.8	Water Pump	1.0	lumpsum	3500.00	500.00	4,000.00
1.9	Miscellaneous 10%	1.0	lumpsum	-	-	4,890.00
	Sub-Total			24,570.00	5,630.00	53,790.00
2	***Standard deck 5m x 5m W/ deck 5m x 5m***					
	Excavation+Backfill	12.5	cu.m.	-	55.00	687.50
	RC. Slab	7.5	cu.m.	750.00	350.00	8,250.00
	Sub-Total			750.00	405.00	8,937.50
2.1	Design&Preparing site	5%				446.88
2.2	Building + Pre-Load Area	50%				4,468.75
2.3	Equipment	20%				1,787.50
2.4	Labour	20%				1,787.50
2.5	Construction tools	5%				446.88
3	***Yearly maintenance***	***1***	***times***			
	Miscellaneous (5% of building cost)	1.0	lumpsum			3,136.38
3.1	Maintaining site condition	100%				3,136.38

Option III (farm size > 50 rais)

No.	Description	Q'ty	Unit	Material	Labour	Total
1	***Standard Building size 6.5m x 6.5m***					
1.1	Excavation+Backfill	25.0	cu.m.	-	55.00	1,375.00
1.2	RC. Slab	15.0	cu.m.	750.00	350.00	16,500.00
1.3	Block wall	48.0	sq.m.	140.00	75.00	10,320.00
1.4	Roofing	30.0	sq.m.	180.00	150.00	9,900.00
1.5	Accessories (door, window, etc.)	1.0	lumpsum	10,000.00	500.00	10,500.00
1.6	Electrical and Mechanical works	1.0	lumpsum	12500.00	2500.00	15,000.00
1.7	Chemical Storage Tank	1.0	lumpsum	10000.00	1500.00	11,500.00
1.8	Water Pump	1.0	lumpsum	6000.00	500.00	6,500.00
1.8	Miscellaneous 10%	1.0	lumpsum	-	-	8,159.50
	Sub-Total			39,570.00	5,630.00	89,754.50
2	***Standard deck 5m x 5m W/ deck 5m x 5m***					
	Excavation+Backfill	12.5	cu.m.	-	55.00	687.50
	RC. Slab	7.5	cu.m.	750.00	350.00	8,250.00
	Sub-Total			750.00	405.00	8,937.50
2.1	Design&Preparing site	5%				446.88

2.2	Building + Pre-Load Area	50%				4,468.75
2.3	Equipment	20%				1,787.50
2.4	Labour	20%				1,787.50
2.5	Construction tools	5%				446.88
3	***Yearly maintenance***	***1***	***times***			
	Miscellaneous (5% of building cost)	1.0	lumpsum			4,934.60
3.1	Maintaining site condition	100%				4,934.60

T12 Riparian Setback (for an area of 1,296 m^2)

No.	Description	Q'ty	Unit	Material	Labour	Total
1	***First-time planting (Buffer width 36m)***	***1296.0***	***sq.m.***	***0.50***	***3.50***	***5,184.00***
	- including clearing, tilage, and planting					
1.1	Preparing riparian area	25%				1,296.00
1.2	Planting/Seeding	75%				3,888.00
2	***Annual maintenance***	***1296.0***	***sq.m.***	***-***	***0.50***	***648.00***
2.1	Maintaining riparian plant	70%				453.60
2.2	Replanting some destroyed area	30%				194.40

Annex 3: Cost estimate of a mix-load and wash-down site

Assumptions & Calculations:

Installation costs

1. The permanent station comprises of
   a. Wash-down and mixing –loading area, and
   b. Pesticide storage area

   The literatures show that the size of functional areas of an operation is dependent on the amount of pesticide stored at the facility and the number of employees (Kammel and O'Neil 1990). Thus, the wash-down and mix-load area will be treated as fixed installation cost, while the storage area will be treated as variable installation cost. The total cost has a characteristic of mixed-cost with a step-function relationship with farm size.

   Further, the maintenance cost and opportunity cost will vary depending on the total mixed-cost

2. For the fixed installation cost it is assumed that the effective functional area of wash-down and mixing-loading area is 5m x 5m (or 25 m^2) for every farm size. The total fixed installation cost is 1,787.50/ rai/ year

3. For the variable installation cost, based on the observation of chemical purchasing behaviour of farmers the analysis will divide farm size into three categories. These are
   a. Farm size < 10 rais
   b. 10.01 – 50 rais, and
   c. Farm size > 50 rais

4. It is assumed that the chemical procurement is done twice a year.

5. A basic 2-storey shelf with an area of $1m^2$ can store pesticide package sized $2m^2$.

6. A work by Dean (2004) states that at least 10% more space than that needed for the largest amount of pesticide even expected to be stored is what farmer must have. The total amount of pesticide to be stored is calculated based on the pesticide application surveyed by Uchiyama et al. (2007).

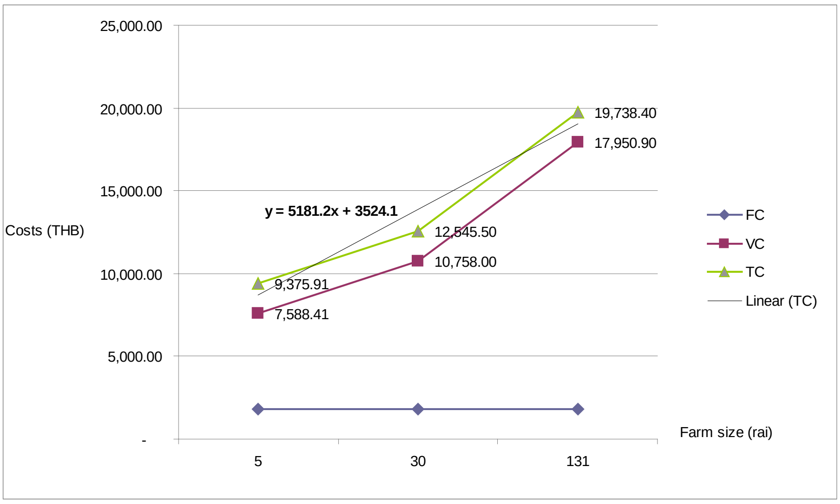
7. The storage was calculated based on engineer estimation

Farm size (rai)	Storage area required (m^2)
< 10 rais	2.5m x 2.5m = 6.25 m^2
10.01 – 50 rais	4m x 4m = $16m^2$
> 50 rais	6.5m x 6.5m = $42.25m^2$

8. The total variable costs is thus,

Farm size (rai)	Total variable cost (THB)/ rai/ year
< 10 rais	7,588.41
10.01 – 50 rais	10,758.00
> 50 rais	17,950.90

9. A step function of total cost and farm size is plotted to find a representative equation.



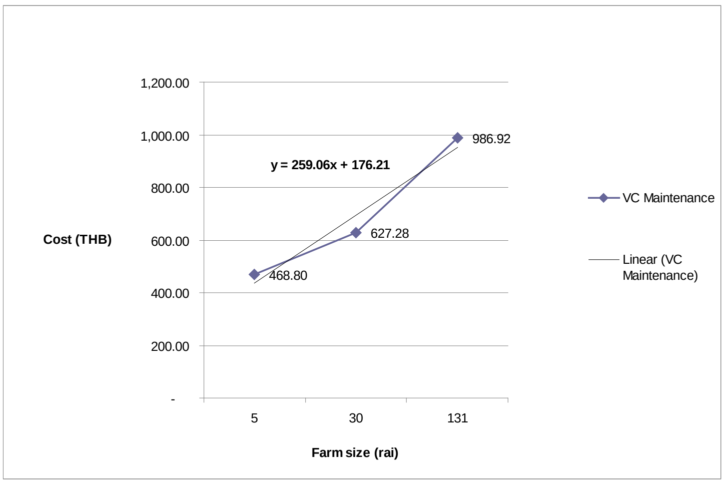
10. The total cost equation show that the average total installation costs is 5,181.20THB/ rai/ year

<u>Maintenance costs</u>

1. The maintenance cost is 5% of total installation costs. Thus,

Farm size (rai)	Total maintenance cost (THB)/ rai/ year
< 10 rais	468.80
10.01 – 50 rais	627.72
> 50 rais	5,654.26

2. A step function of total maintenance cost and farm size is plotted to find a representative equation



3. The total cost equation show that the average total maintenance costs is 259.06THB/ rai/ year

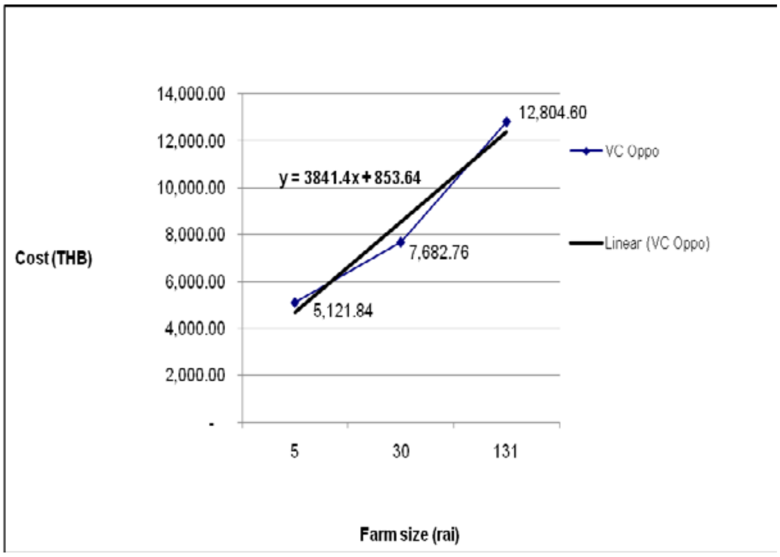
Opportunity costs

1. The opportunity cost is as follows:

Farm size (rai)	Land opportunity cost (THB)/ rai/ year
< 10 rais	5,121.84[a]
10.01 – 50 rais	7,682.76[b]
> 50 rais	12,804.60[c]

Notes: a) four trees removed; b) six trees removed; c) ten trees removed

2. A step function of total opportunity cost and farm size is plotted to find a representative equation



3. The total cost equation shows that the average total opportunity costs is 3,841.40THB/ rai/ year based on the returns over variable costs (THB1,280.46 per tree)

Annex 4: Questions for elicitation study

Guide for Interviewer

Good morning. We are from … and we conduct a study of citrus growers in the Ping river basin. We are interested in the reasons why growers do or do not adopt BMPs in their farms. Please tell us what you are really thinking. There is no right or wrong answer.
The scenarios describing 1) benefits from watershed services, 2) effects of farm nonpoint source pollution, and 3) BMPs will be given to participants, and then questions will be asked.

Participants will be notified that

- BMPs are voluntary measure which is likely to be promoted by the state government in the near future.
- There is no ideal management practices system for controlling a particular pollutant in all situations. The system should be designed based on the type of pollutant, the source of the pollutant, the cause of pollutant, the agricultural climatic and environmental conditions, and the willingness and ability of the citrus growers in implement and maintain the practices.

A: Background

Name: …………………………………….
Age: ………. years
Gender: ………..Male ……….Female
Address: ………………………………………

B: Intentions

1 Given three scenarios, will you adopt BMPs? (yes/no)
2 On the scale 1 to 7, how difficult is it for you to make a decision? *(1 = not at all difficult, 7 = extremely difficult)* …………….

C: Attitudes

3 What do you believe are the advantages of BMPs adoption?
4 What do you believe are the disadvantages of BMPs adoption?
5 Is there anything else you associate with your own views about BMPs adoption?

D: Subjective norms

6 Are they any individual or groups who would support or facilitate if you are going to adopt BMPs?
7 Are they any individual or groups who would resist or retard if you are going to adopt BMPs?
8 Is there anything else you associate with other people's views about BMPs adoption?

E: Perceived behavioural control

9 What factors or circumstances enable you to adopt BMPs?
10 What factors or circumstances make it difficult or impossible for you to adopt BMPs?
11 Are there any other issues that come to mind when you think about BMPs adoption?

F: Current situation

12 At present, is there any conservation practice done in you fields, and if 'yes' what?
13 In your opinion, which practices are likely to be done (by yourself) in your farm, and which practices should be promoted by external agencies such as government, farmer association?

Thai version

คำชี้แจง: คณะวิจัยทำการศึกษาเกษตรกรผู้ปลูกส้มในเขตลุ่มน้ำปิง โดยมีวัตถุประสงค์เพื่อ ศึกษาทัศนคติของเกษตรกรต่อการประยุกต์ใช้ "***เกณฑ์การปฏิบัติที่ดี***" (Best Management Practices) ในสวนส้ม ก่อนทำการสัมภาษณ์ ผู้สัมภาษณ์จะอธิบายถึง ประโยชน์ของลุ่มน้ำ, มลพิษทางน้ำอันเกิดจากการเพาะปลูกส้ม และมาตรการต่างๆ ตามเกณฑ์การปฏิบัติที่ดีที่ควรทำในสวนส้ม เนื่องจากคำถามมีลักษณะปลายเปิด ดังนั้น จึงไม่มีคำตอบที่ถูกหรือผิด

เหตุการณ์สมมติ

1) คณะวิจัยนำเสนอภาพลุ่มน้ำและประโยชน์ที่ได้รับจากลุ่มน้ำแก่ผู้ตอบแบบสอบถาม
2) คณะวิจัยนำเสนอภาพมลพิษทางน้ำ อันเกิดจากการเพาะปลูกส้ม หลังจากนั้นจะนำเสนอภาพแผนที่ระดับคุณภาพน้ำของประเทศไทย โดยเปรียบเทียบให้เห็นถึงความแตกต่างระหว่างคุณภาพน้ำระดับประเทศและคุณภาพน้ำในพื้นที่ศึกษา
3) คณะวิจัยนำเสนอแนวทางต่างๆ ตามเกณฑ์การปฏิบัติที่ดี พร้อมทั้งวิธีการประยุกต์ใช้ในสวนส้มแก่ผู้ตอบแบบสอบถาม

<u>หมายเหตุ</u>: ก่อนเข้าสู่การอธิบายเหตุการณ์จำลองที่ 3 คณะวิจัยจะอธิบายเพิ่มเติมให้ผู้ตอบแบบสอบถามเข้าใจในเบื้องต้น ดังนี้

- เกณฑ์การปฏิบัติที่ดีในสวนส้มเป็นมาตรการที่ใช้กันอย่างแพร่หลายในประเทศพัฒนาแล้ว อาทิเช่น ในรัฐฟลอริด้า ประเทศสหรัฐอเมริกา และในอนาคตอันใกล้รัฐบาลอาจจะประกาศใช้มาตรการดังกล่าวกับสวนส้มในประเทศ

- การประยุกต์ใช้เกณฑ์การปฏิบัติที่ดีในสวนส้มไม่มีลักษณะตายตัว กล่าวคือ การเลือกใช้มาตรการหนึ่งมาตรการใดขึ้นอยู่กับลักษณะของมลพิษ, แหล่งกำเนิดมลพิษ, รูปแบบการเพาะปลูก, สภาพดินฟ้าอากาศ สภาวะแวดล้อม ตลอดจนความตั้งใจและความต้องการนำไปปฏิบัติของเกษตรกรเอง

ก) ข้อมูลพื้นฐาน

ชื่อ ……………………………………………………………………………………………………….

อายุ ……………………ปี

เพศ ☐ ชาย ☐ หญิง

ที่อยู่ …………………………………………………………………………………………………........

หมายเลขโทรศัพท์ …………………………………………………………………………………………

ข) ความตั้งใจนำไปปฏิบัติ

1. จากเหตุการณ์สมมติที่ได้นำเสนอไปนั้น ท่านพิจารณาแล้วยินดีจะนำเกณฑ์การปฏิบัติที่ดีไปประยุกต์ใช้ในสวนส้มของท่านหรือไม่? (ยินดี/ ไม่ยินดี)
2. การที่ท่านตอบว่า ยินดี (หรือ ไม่ยินดี) นำเกณฑ์การปฏิบัติที่ดีไปปฏิบัติใช้ในสวนส้มนั้น ท่านรู้สึกลำบากใจในการตอบมากน้อยเพียงใด (1 = ไม่รู้สึกลำบากใจแม้แต่น้อย, 7 = ลำบากใจในการตัดสินใจมาก)

ค) ทัศนคติต่อเกณฑ์การปฏิบัติที่ดี

3. ท่านคิดว่าการนำเกณฑ์การปฏิบัติที่ดีไปใช้ในสวนส้มของท่านจะก่อให้เกิด ผลดี อย่างไร?
4. ท่านคิดว่าการนำเกณฑ์การปฏิบัติที่ดีไปใช้ในสวนส้มของท่านจะก่อให้เกิด ผลเสีย อย่างไร?
5. ในมุมมองของท่าน ท่านมีข้อเสนอแนะเพิ่มเติมเกี่ยวกับการประยุกต์ใช้เกณฑ์การปฏิบัติที่ดีในสวนส้มหรือไม่? อย่างไร?

ง) ความเชื่อส่วนบุคคล

6. สมมติว่า ท่านจะนำเกณฑ์การปฏิบัติที่ดีมาใช้ในสวนส้มของท่าน ท่านคิดว่าจะมีบุคคล/ หรือองค์กรใดให้การ สนับสนุนหรือช่วยเหลือ?
7. สมมติว่า ท่านจะนำเกณฑ์การปฏิบัติที่ดีมาใช้ในสวนส้มของท่าน ท่านคิดว่าจะมีบุคคล/ หรือองค์กรใดคัดค้าน หรือไม่เห็นด้วย?
8. ในมุมมองของท่าน ท่านคิดว่าคนอื่นจะคิดอย่างไร หากท่านนำเกณฑ์การปฏิบัติที่ดีมาใช้ในสวนส้มของท่าน?

จ) ปัจจัยแวดล้อม

9. มีปัจจัย หรือ องค์ประกอบใด ที่จะส่งเสริมให้ท่านนำเกณฑ์การปฏิบัติที่ดีไปใช้ในสวนส้มของท่าน?
10. มีปัจจัย หรือ องค์ประกอบใด ที่จะเป็นอุปสรรคต่อการนำเกณฑ์การปฏิบัติที่ดีมาใช้ในสวนส้มของท่าน?
11. ท่านมีความกังวลอะไรบ้าง หากต้องนำเกณฑ์การปฏิบัติที่ดีมาประยุกต์ใช้ในสวนส้มของท่าน?

ฉ) สถานการณ์ปัจจุบัน

12. ในปัจจุบัน ท่านได้ประยุกต์ใช้มาตรการใดๆ ที่ช่วยส่งเสริมการอนุรักษ์สิ่งแวดล้อมบ้างหรือไม่?
13. ในความคิดของท่าน มาตรการใดบ้างที่สามารถนำมาประยุกต์ใช้ หรือปฏิบัติในสวนส้มของท่าน (สามารถทำเองได้), และมีมาตรการใดบ้างที่ควรได้รับการส่งเสริม หรือสนับสนุนให้เกิดในสวนส้มของท่าน (ทำได้โดยมีผู้ให้ความช่วยเหลือ เช่น รัฐบาล, กลุ่มเกษตรกร)

Annex 5: Final questionnaire

QUESTIONNAIRE: Citrus growers' attitudes towards BMPs uptake

We conduct a study of citrus grower in the Ping River Basin, north of Thailand. We are interested in the reasons why citrus growers do or do not adopt **Best Management Practices (BMPs)** in their farms.

First of all, we would like to assure you that the information that you reveal in this interview will be used solely for purpose of research, and that your identity and your answers will be confidentially treated. There is no right or wrong answers, so please tell us what you are really thinking.

Basic information
Name: …………………………………………………………………………………
Address: ………………………………………………………………………………
…….………………………………………….. Province …………………………
Contact number: ………………………………………………………………………
Date of interview: ……………………… Interviwer: ………………………………
Time interview started:……………… Time interview ended: …………………

Prior to asking citrus growers' perception of BMPs adoption, an interviewer will describe the role of watershed and its natural services, followed by effects from diffuse pollution possibly generated by citrus production. The scientific information regarding water quality in the Ping river basin compared with other river basins will be also demonstrated to participants using a water quality map.

SECTION 1: *Intention simulation*

This section aims to find out which BMPs that are likely to be implemented in citrus farm(s). Interviewer will describe all 12 BMPs (give information of technology attributes and cost descriptions, not cost figures), and then ask citrus growers to choose only **three practices** they would like to operate in priority order in their farm.

Three adopted BMPs will be recorded in SHEET 1.

SHEET 1	
Three preferrable practices to be implemented in your farm	
Practice	....
Practice	....
Practice	....

SECTION 2: ***Your thinkings***

This section aims to gain insightful responses from citrus growers in to what extent they think about adopting BMPs in their farm(s). There are 35 statements, and respondents will be asked in which degree (7-point scale) they agree with each statement. All respondents will be given the same situational condition which is If the government asks for voluntary adoption, consider the case of **adopting activities that could reduce amount of pollutants discharged into watercourses in the next three years**. (carefully think about what you have just chose as your first three choices)

Please tell us how you feel about BMP uptake.

1	Overall, I think that adopting BMPs in my citrus farm is:			
		Good	o—o—o—o—o—o—o	Bad
		Worthless	o—o—o—o—o—o—o	Useful
		The right thing to do	o—o—o—o—o—o—o	The wrong thing to do
		Plesant (for me)	o—o—o—o—o—o—o	Unplesant (for me)
2	For me, to adopt BMPs is	Easy	o—o—o—o—o—o—o	Difficult

Please tell us in which degree you agree with below statements

3	It is expected for me that I should adopt BMPs in my citrus farm	Strongly disagree	o—o—o—o—o—o—o	Strongly agree
4	I feel under social pressure to adopt BMPs in my citrus farm	Strongly disagree	o—o—o—o—o—o—o	Strongly agree
5	People who are important to me want me to adopt BMPs in my citrus farm	Strongly disagree	o—o—o—o—o—o—o	Strongly agree
6	I am confident that I could adopt BMPs in my citrus farm if I wanted to	Strongly disagree	o—o—o—o—o—o—o	Strongly agree
7	The decision to adopt BMPs is beyond my control	Strongly disagree	o—o—o—o—o—o—o	Strongly agree
8	Whether I adopt BMPs or not is entirely up to me	Strongly disagree	o—o—o—o—o—o—o	Strongly agree
9	If I adopt BMPs, I can reduce production cost	Strongly disagree	o—o—o—o—o—o—o	Strongly agree
10	An adoption of BMPs will protect the environment	Strongly disagree	o—o—o—o—o—o—o	Strongly agree
11	If I adopt BMPs, I will gain more benefits from watershed services	Strongly disagree	o—o—o—o—o—o—o	Strongly agree
12	An adoption of BMPs will induce a great commitment of farm management	Strongly disagree	o—o—o—o—o—o—o	Strongly agree
13	I can easily afford to pay for any practice following BMPs' regulation	Strongly disagree	o—o—o—o—o—o—o	Strongly agree

14	When adopting BMPs, I am afraid that I might loss	Strongly disagree	○—○—○—○—○—○—○	Strongly agree
15	I know exactly how to conduct each practice properly	Strongly disagree	○—○—○—○—○—○—○	Strongly agree
16	The existence of farmers' association enable me to adopt BMPs	Strongly disagree	○—○—○—○—○—○—○	Strongly agree
17	There is a potential market where I can sell my chemical-free product	Strongly disagree	○—○—○—○—○—○—○	Strongly agree
Please tell us how you feel about the following statements				
18	Reducing production cost is:	Extremely bad	○—○—○—○—○—○—○	Extremely good
19	For me, to protect the environment is:	Extremely bad	○—○—○—○—○—○—○	Extremely good
20	Gaining more benefits from watershed is:	Extremely bad	○—○—○—○—○—○—○	Extremely good
21	For me, Induced to a great commitment of farm management is:	Extremely bad	○—○—○—○—○—○—○	Extremely good
In which degree do you think that people below would like you to adopt BMP in your farm?				
22	Consumers would think that I	should not	○—○—○—○—○—○—○	should
23	The government would think that I	should not	○—○—○—○—○—○—○	should
24	The agricultural input retailers would think that I	should not	○—○—○—○—○—○—○	should
25	Most people who are important to me think that I	should not	○—○—○—○—○—○—○	should
Will your neighbour adopt BMP in his/her farms?				
26	My neighbours	will not	○—○—○—○—○—○—○	will
Are you tending to do what your neighbours do?				
27	Doing what my neighbours do is important to me	Not at all	○—○—○—○—○—○—○	Very much
Please tell us how much do you care what these people think you should do?				
28	Consumers	Not at all	○—○—○—○—○—○—○	Very much
29	Government	Not at all	○—○—○—○—○—○—○	Very much
30	Agricultural input retailers	Not at all	○—○—○—○—○—○—○	Very much
When considering these things below, will you adopt BMP in your farm?				
31	I am affordable for any practice	Less likely	○—○—○—○—○—○—○	More likely
32	Returns after BMP uptake	Less likely	○—○—○—○—○—○—○	More likely
33	I have enough knowledge to conduct proper BMPs	Less likely	○—○—○—○—○—○—○	More likely
34	Strong and effective farmer's association	Less likely	○—○—○—○—○—○—○	More likely
35	There is potential market to sell my chemical-free fruit	Less likely	○—○—○—○—○—○—○	More likely

SECTION 3: *About your Backgroud*				
36	Gender: ☐ Male	☐ Female		
37	Age: .... Years			
38	Education level	☐ elementary school	☐ some high school	☐ high school
		☐ college/ diploma	☐ postgraduate	
39	Land ownership	☐ owner	☐ tenant	☐ illegal occupier
40	Farm size: .... Rais			
41	Location of farm	☐ upstream	☐ downstream	
42	Does stream ran through your farm?	☐ Yes	☐ No	
43	Soil type	☐ clay	☐ loam	
		☐ sandy loam	☐ sandy	
44	How long have you farmed?	.... Years		
45	Do you have any health problem since you have started citurs cultivation?	☐ No	☐ Yes, specify	
46	How many family members work on your farm? (including yourself)	.... (number)		
47	How many non-family member employees work on your farm?	Part-time ..../ Full-time .... (number)		
48	Do you have other crops raised for sale or feeding?	☐ Yes	☐ No	
49	Are you a member of any association promoting sustainable farm management?	☐ No	☐ Yes, specify	
50	If you are faced with problems and want to consult with government agency, how difficult to reach him?	☐ easy	☐ not that easy	
		☐ not so difficult	☐ difficult	
51	If you are faced with problems and want to consult with other specialists, how difficult to reach them?	Please specify:		
		☐ easy	☐ not that easy	
		☐ not so difficult	☐ difficult	
52	Household income (before tax) ....Baht (enumerator sees *Note* below)			
53	Household debt .... Baht (enumerator sees Note below)			

If participant has any additional comments about water quality, nonpoint source pollution, and / or BMP in the citrus production, please indicate them in the space provided.

....

....

Experience of interviewer about particpant (i.e. reactions of participant, difficulties during interview, etc.)

....

....

Note. Total household income = Farm income + Off farm income
Total household debt = all kinds of loan and borrowing (plus interest)

Thai version

แบบสอบถามทัศนคติของเกษตรกรต่อการประยุกต์ใช้เกณฑ์การปฏิบัติที่ดี (Best Management Practices: BMPs) ในสวนส้ม

คณะศึกษาจากมหาวิทยาลัยเอดินเบิร์ก ประเทศสหราชอาณาจักร มีความสนใจทำการศึกษาเพื่อรับทราบทัศนคติของเกษตรกรในเขตลุ่มน้ำปิงต่อการประยุกต์ใช้เกณฑ์การปฏิบัติที่ดีในสวนส้ม โดยมีวัตถุประสงค์เพื่อต้องการทราบว่าเกษตรกรมีความต้องการนำเกณฑ์การปฏิบัติที่ดีดังกล่าวไปใช้ในสวนส้มตนเองหรือไม่ และอะไรคือสาเหตุของการนำไปประยุกต์ใช้

ในการสำรวจครั้งนี้ คณะผู้สำรวจจะใช้คำถามจากแบบสอบถามและทำการสัมภาษณ์โดยตรงจากเกษตรกร ผลการสำรวจจะถูกนำไปใช้เพื่อการศึกษาและนำเสนอแนวทางในการวางนโยบายที่เหมาะสมสำหรับหน่วยงานรัฐบาลที่เกี่ยวข้องเท่านั้น เนื่องจากการตอบคำถามครั้งนี้คณะศึกษาต้องการรับทราบถึงความคิดเห็นของเกษตรกรที่มีต่อการประยุกต์ใช้เกณฑ์การปฏิบัติที่ดี ดังนั้นการตอบคำถามจึงไม่มีคำตอบที่ "ถูก" หรือ "ผิด"

ข้อมูลทั่วไป

ชื่อ-สกุล: …………………………………………………………………………………………….

ที่อยู่: ……………………………………………………………………………........……………………

……………………………………………………. จังหวัด ………………………….

เบอร์ติดต่อ: ……………………………………………………………………….

วันที่สัมภาษณ์: ……………………………… ผู้สัมภาษณ์: ……………………………………...

เวลาเริ่มสัมภาษณ์: ……………………… เวลาเลิกสัมภาษณ์: …………………………….

ก่อนเริ่มการสัมภาษณ์ คณะศึกษาจะอธิบายให้เกษตรกรรับทราบถึง 1) ความสำคัญของลุ่มน้ำและบทบาทของลุ่มน้ำกับระบบนิเวศน์, 2) มลพิษทางน้ำที่เกิดขึ้นจากการทำสวนส้ม, 3) คุณภาพน้ำในลุ่มน้ำปิงเมื่อเปรียบเทียบกับลุ่มน้ำอื่นๆ และ 4) เกณฑ์การปฏิบัติที่ดีทั้ง 12 ประการ

ส่วนที่ 1: *ความตั้งใจนำไปปฏิบัติ*

<u>วัตถุประสงค์</u>: เพื่อต้องการทราบว่าเกณฑ์การปฏิบัติที่ดีประการใดบ้างที่เกษตรกรต้องการนำไปประยุกตุใช้ในสวนส้มของตนเอง

คณะศึกษาจะนำเสนอ 12 แนวทางเลือกตามเกณฑ์การปฏิบัติที่ดี พร้อมทั้งข้อดีและรายละเอียดด้านต้นทุนในการนำไปปฏิบัติ จากนั้นจะถามความต้องการนำไปประยุกต์ใช้ของเกษตรกร โดยให้เกษตรกรเลือก **<u>3 แนวทาง</u>**ที่ตนเองอยากนำไปปฏิบัติในสวนส้มมากที่สุด (จากต้องการมากที่สุดไปน้อยที่สุด)

1) หากเกษตรกรเลือกที่จะ **ประยุกต์** คำตอบจะถูกบันทึกลงใน **SHEET 1**

SHEET 1

3 แนวทางเลือกที่<u>อยาก</u>นำมาปฏิบัติในสวนส้มของท่านมากที่สุด

แนวทางเลือกที่ ……………………..

แนวทางเลือกที่ ……………………..

แนวทางเลือกที่ ……………………..

1

ส่วนที่ 2: *ความคิดเห็นของเกษตรกร*

<u>วัตถุประสงค์</u>: เพื่อต้องการรับทราบทัศนคติของเกษตรกรที่มีต่อเกณฑ์การปฏิบัติที่ดีโดยรวม

คณะศึกษาเริ่มถามคำถามโดยสมมติเหตุการณ์ดังนี้ **"เพื่อเป็นการลดปริมาณมลพิษที่ปล่อยลงสู่แหล่งน้ำธรรมชาติ รัฐบาลต้องการให้เกษตรกรนำเกณฑ์การปฏิบัติที่ดีไปใช้ในสวนส้มภายในระยะเวลาอีก 3 ปีข้างหน้า ให้เกษตรกรลองนึกถึงการประยุกต์ใช้แนวทางเลือกทั้ง 12 ทาง ซึ่งเกษตรกรอาจเลือกปฏิบัติเพียง 1 ทางเลือกหรือมากกว่านั้นก็ได้"** เกษตรกรจะรู้สึกอย่างไรกับคำถามต่อไปนี้

ท่าน<u>รู้สึกอย่างไร</u>กับคำถามต่อไปนี้

ข้อ	คำถาม			
1	โดยทั่วไป ฉันคิดว่าการนำเกณฑ์การปฏิบัติที่ดีมาใช้ในสวนส้มของฉัน:			
		เป็นสิ่งที่ดี	○—○—○—○—○—○—○	เป็นสิ่งไม่ดี
		ไม่มีประโยชน์	○—○—○—○—○—○—○	มีประโยชน์
		เป็นสิ่งที่ควรทำ	○—○—○—○—○—○—○	เป็นสิ่งไม่ควรทำ
		ฉันอยากทำ	○—○—○—○—○—○—○	ฉันไม่อยากทำ
2	สำหรับฉัน การนำเกณฑ์ดังกล่าวมาปฏิบัติในสวนส้ม	เป็นเรื่องง่าย	○—○—○—○—○—○—○	เป็นเรื่องยาก

ท่าน<u>เห็นด้วย</u>หรือ<u>ไม่เห็นด้วย</u>กับสิ่งที่ผู้สัมภาษณ์กำลังจะถามท่าน

ข้อ	คำถาม			
3	คนที่รู้จักฉันคิดว่าฉันควรจะนำเกณฑ์ดังกล่าวมาใช้ในสวนส้มของฉัน	ไม่เห็นด้วย	○—○—○—○—○—○—○	เห็นด้วย
4	คนในท้องถิ่นของฉันมีส่วนผลักดันให้ฉันประยุกต์ใช้เกณฑ์ดังกล่าวในสวนส้ม	ไม่เห็นด้วย	○—○—○—○—○—○—○	เห็นด้วย
5	คนที่ใกล้ชิดฉัน ต้องการให้ฉันนำเกณฑ์ดังกล่าวมาใช้ใสวนส้ม	ไม่เห็นด้วย	○—○—○—○—○—○—○	เห็นด้วย
6	ฉันมั่นใจว่า ฉันสามารถปฏิบัติตามเกณฑ์ดังกล่าวได้ ถ้าฉันมีความตั้งใจจริง	ไม่เห็นด้วย	○—○—○—○—○—○—○	เห็นด้วย
7	ฉันไม่มีอำนาจตัดสินใจว่าจะนำเกณฑ์ดังกล่าวมาปฏิบัติหรือไม่	ไม่เห็นด้วย	○—○—○—○—○—○—○	เห็นด้วย
8	การตัดสินใจว่าจะนำเกณฑ์ดังกล่าวมาใช้ในสวนส้มหรือไม่นั้น ไม่ได้ขึ้นอยู่กับฉันคนเดียวเท่านั้น	ไม่เห็นด้วย	○—○—○—○—○—○—○	เห็นด้วย
9	การนำเกณฑ์ดังกล่าวมาใช้ สามารถช่วยลดต้นทุนการผลิตได้	ไม่เห็นด้วย	○—○—○—○—○—○—○	เห็นด้วย
10	การประยุกต์ใช้เกณฑ์ดังกล่าวจะช่วยรักษาสภาพแวดล้อม	ไม่เห็นด้วย	○—○—○—○—○—○—○	เห็นด้วย
11	การประยุกต์ใช้เกณฑ์ดังกล่าวจะทำให้ฉันได้รับประโยชน์จากลุ่มน้ำมากขึ้น	ไม่เห็นด้วย	○—○—○—○—○—○—○	เห็นด้วย
12	การประยุกต์ใช้เกณฑ์ดังกล่าว เป็นการเพิ่มงานในสวนส้มของฉัน	ไม่เห็นด้วย	○—○—○—○—○—○—○	เห็นด้วย
13	ฉันสามารถรับผิดชอบค่าใช้จ่ายที่จะเกิดขึ้นจากการนำเกณฑ์ดังกล่าวมาปฏิบัติในสวนส้มของฉันได้	ไม่เห็นด้วย	○—○—○—○—○—○—○	เห็นด้วย
14	ฉันอาจขาดทุนถ้านำเกณฑ์ดังกล่าวมาใช้ในสวนของฉัน	ไม่เห็นด้วย	○—○—○—○—○—○—○	เห็นด้วย
15	ฉันมีความรู้อย่างเพียงพอในการปฏิบัติตามเกณฑ์ดังกล่าว	ไม่เห็นด้วย	○—○—○—○—○—○—○	เห็นด้วย

16	การมีกลุ่มเกษตรกรสวนส้มเป็นส่วนหนึ่งที่ทำให้ฉันเลือกที่จะปฏิบัติตามเกณฑ์	ไม่เห็นด้วย	○—○—○—○—○—○—○	เห็นด้วย
17	ถ้าฉันผลิตส้มปลอดสารพิษ จะมีตลาดรองรับผลผลิตของฉัน	ไม่เห็นด้วย	○—○—○—○—○—○—○	เห็นด้วย

ท่านคิดว่าสิ่งเหล่านี้เป็นสิ่งที่ดีหรือไม่ดี

18	การลดต้นทุนการผลิต	ไม่ดี	○—○—○—○—○—○—○	ดี
19	การรักษาสิ่งแวดล้อม	ไม่ดี	○—○—○—○—○—○—○	ดี
20	การได้รับประโยชน์มากขึ้นจากลุ่มน้ำ	ไม่ดี	○—○—○—○—○—○—○	ดี
21	ภาระที่เพิ่มขึ้นในการทำสวนส้มหลังจากเลือกที่จะปฏิบัติตามเกณฑ์ดังกล่าว	ไม่ดี	○—○—○—○—○—○—○	ดี

ท่านคิดว่าบุคคลเหล่านี้ต้องการให้ท่านประยุกต์ใช้เกณฑ์ดังกล่าวมากน้อยแค่ไหน

22	ผู้บริโภค อยากให้ฉัน	ไม่ประยุกต์	○—○—○—○—○—○—○	ประยุกต์
23	รัฐบาลอยากให้ฉัน	ไม่ประยุกต์	○—○—○—○—○—○—○	ประยุกต์
24	ร้านขายเครื่องมือทางการเกษตรอยากให้ฉัน	ไม่ประยุกต์	○—○—○—○—○—○—○	ประยุกต์
25	คนที่ใกล้ชิดฉัน อยากให้ฉัน	ไม่ประยุกต์	○—○—○—○—○—○—○	ประยุกต์

ท่านคิดว่า เพื่อนบ้านของท่านจะประยุกต์ใช้เกณฑ์ดังกล่าวในสวนส้มของเขาหรือไม่

26	เพื่อนบ้านของฉัน	ไม่ประยุกต์	○—○—○—○—○—○—○	ประยุกต์

ท่านจะมีแนวโน้มที่จะปฏิบัติตามเพื่อนบ้านมากน้อยเพียงใด (เช่น พฤติกรรมการใช้สารเคมี การดูแลคูคลอง การดูแลรักษาสวนส้ม ฯลฯ)

27	ฉัน	ไม่ทำตามเลย	○—○—○—○—○—○—○	ฉันทำตามเป็นประจำ

เวลาที่ท่านต้องตัดสินใจในเรื่องใดๆ ก็ตามที่เกี่ยวข้องกับกิจกรรมทางการเกษตร ท่านสนใจความรู้สึกของบุคคลเหล่านี้มากน้อยแค่ไหน

28	ผู้บริโภค	ไม่เลย	○—○—○—○—○—○—○	มาก
29	นโยบายของรัฐบาล	ไม่เลย	○—○—○—○—○—○—○	มาก
30	เจ้าของร้านขายเครื่องมือทางการเกษตร	ไม่เลย	○—○—○—○—○—○—○	มาก

เมื่อพิจารณาถึงสิ่งต่อไปนี้ ท่านจะประยุกต์ใช้เกณฑ์ดังกล่าวในสวนส้มของท่านหรือไม่

31	ท่านมีเงินลงทุน	ไม่มีทางประยุกต์	○—○—○—○—○—○—○	ประยุกต์แน่นอน
32	ผลตอบแทนที่จะได้รับ (ทั้งที่เป็นรายได้และไม่ใช่รายได้ เช่น คุณภาพชีวิต)	ไม่มีทางประยุกต์	○—○—○—○—○—○—○	ประยุกต์แน่นอน
33	ท่านมีความรู้ในการนำเกณฑ์ดังกล่าวไปปฏิบัติอย่างถูกต้อง	ไม่มีทางประยุกต์	○—○—○—○—○—○—○	ประยุกต์แน่นอน
34	มีกลุ่มเกษตรกรที่เข้มแข็ง	ไม่มีทางประยุกต์	○—○—○—○—○—○—○	ประยุกต์แน่นอน
35	มีตลาดรองรับผลผลิตปลอดสารพิษ	ไม่มีทางประยุกต์	○—○—○—○—○—○—○	ประยุกต์แน่นอน

ส่วนที่ 3: ข้อมูลส่วนตัว

36 เพศ: ☐ชาย ☐หญิง			
37 อายุ: …………………… ปี			
38 ระดับการศึกษา	☐ ป.1 - ป.6	☐ ม.1 - ม.5	☐ ม.6
	☐ ปวช./ ปวส.	☐ ปริญญาตรี	☐ อื่นๆ …………………
39 การถือครองที่ดิน	☐ เจ้าของ	☐ เช่า	☐ เข้าทำเปล่า
40 พื้นที่สวนส้ม: ……………. ไร่			
41 ที่ตั้งสวนส้ม	☐ ต้นน้ำ	☐ ท้ายน้ำ	
42 สวนส้มของท่านมีลำธารไหลผ่าน	☐ ใช่	☐ ไม่ใช่	
43 สภาพดินในสวนส้มของท่าน เป็น	☐ ดินเหนียว	☐ ดินร่วน	
	☐ ดินทราย	☐ ดินร่วนปนทราย	
44 ท่านทำสวนส้มมากี่ปีแล้ว	……………… ปี		
45 ตั้งแต่เริ่มทำสวนส้ม ท่านมีปัญหาทางสุขภาพหรือไม่	☐ ไม่มี	☐ มี คือ …………………………….......	
46 จำนวนสมาชิกในครัวเรือนที่ทำงานในสวนส้ม (รวมผู้ตอบแบบสอบถาม)	…………… (คน)		
47 จำนวนแรงงานในสวนส้มที่ไม่ได้เป็นสมาชิกในครัวเรือน	แรงงานประจำ …………… (คน)	แรงงานชั่วคราว …………… (คน)	
48 นอกจากส้ม ท่านยังปลูกพืชอื่นสำหรับขายหรือใช้เป็นอาหารในครัวเรือนด้วย	☐ ใช่	☐ ไม่ใช่	
49 ท่านเป็นสมาชิกของกลุ่มเกษตรกรใดๆ บ้างหรือไม่	☐ ไม่เป็น	☐ เป็น คือ ……………………………	
50 เวลาที่มีปัญหาจากการประกอบอาชีพแล้วต้องการปรึกษาเจ้าหน้าที่เกษตร ท่านสามารถเข้าถึงเจ้าหน้าที่เหล่านั้น ..	☐ ได้ง่าย	☐ ค่อนข้างยาก	
	☐ ค่อนข้างง่าย	☐ ได้ยาก	
51 เวลาที่มีปัญหาจากการประกอบอาชีพแล้วต้องการปรึกษาผู้มีความรู้ที่ไม่ใช่เจ้าหน้าที่เกษตร ท่านสามารถเข้าถึงคนเหล่านั้น	โปรดระบุ: ………………………………………………		
	☐ ได้ง่าย	☐ ค่อนข้างยาก	
	☐ ค่อนข้างง่าย	☐ ได้ยาก	
52 รายได้ครัวเรือนปีที่ผ่านมา (ก่อนหักค่าใช้จ่าย) ………………บาท			
53 หนี้สินครัวเรือน ณ ปัจจุบัน (ในระบบ + นอกระบบ) ………………. บาท			

กรณีที่ผู้ตอบแบบสอบถามมีข้อข้องใจเกี่ยวกับเรื่องคุณภาพน้ำ, มลพิษทางน้ำที่เกิดจากสวนส้ม, ตลอดจนเกณฑ์การปฏิบัติที่ดีในสวนส้ม โปรดระบุด้านล่าง
……
……

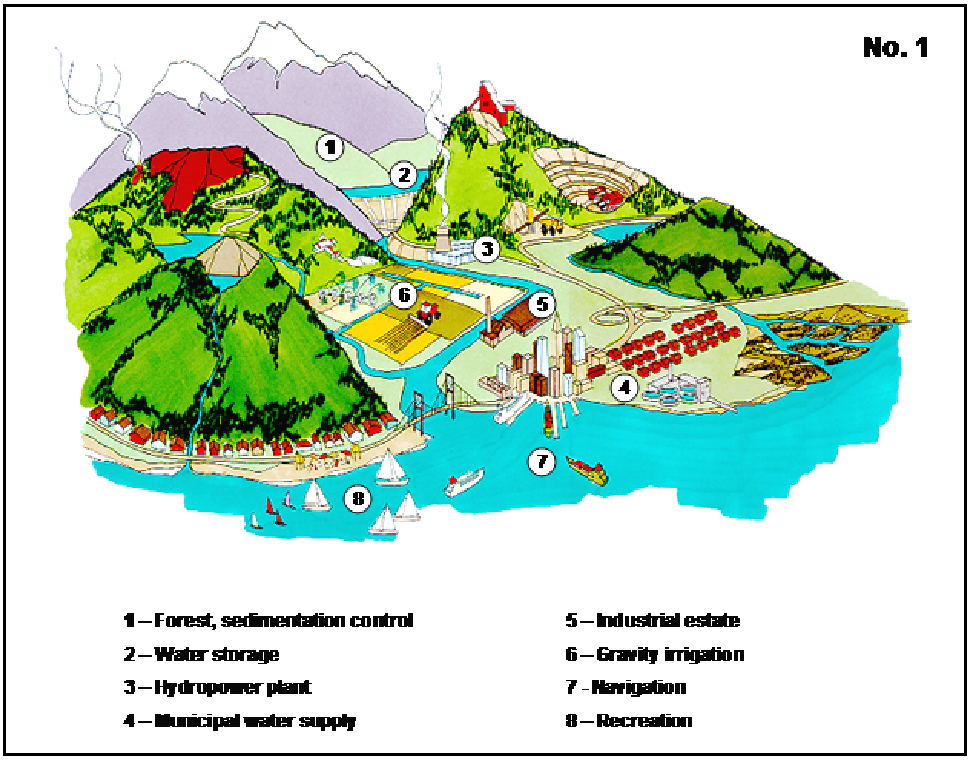
ความรู้สึกของผู้สอบถามต่อท่าทีของเกษตรกรขณะที่ให้สัมภาษณ์ (เช่น ปฏิกริยา, สีหน้าท่าทาง เป็นต้น)
……
……

รายได้ครัวเรือน หมายถึง รายได้ในฟาร์ม + รายได้นอกฟาร์ม

หนี้สินครัวเรือน หมายถึง เงินกู้ยืมทุกประเภท (รวมดอกเบี้ย)

Annex 6: Illustrations for presentation

Roles of watershed services

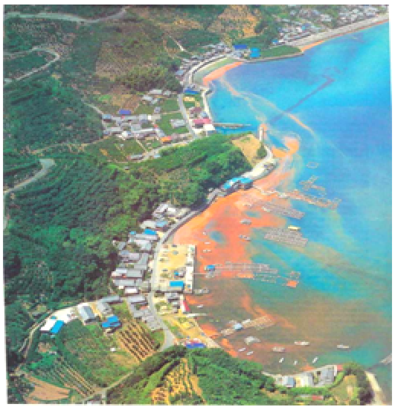


Nonpoint source pollution from farm activities

Water resource management:
water released from irrigated citrus farms can cause

No. 2

Source: www.abc.net.au/m/science/s/features/suitcase/slideshow/thai02.htm



Source: ic.ucsc.edu/~flegal/etox80e/SpecTopics/AlgalBlooms/alg_p1.jpg

Salinity effect: Irrigated water has load of dissolved mineral salts. As water is consumed by plants or lost to atmosphere by evaporation, the salts remain and become concentrated in the soil

Red tide: Irrigation return flow from fields will be reused be farmers in central area and released to Gulf of Thailand. These flows contain nutrient & chemicals that possibly cause red tide in coastal area

No. 3

Erosion control and sediment management:
citrus farms that do not have erosion control and sediment management can cause

Source: www.swwrc.wsu.edu/conference2003f/index.html

Turbidity: Eroded soil particles can be carried by rain or wind to surface water. This will increase the turbidity of the water body. Turbidity reduces light penetration altering oxygen level, thus it reduces the food supply for certain aquatic organisms

Sedimentation: Sedimentation slowly fills in rivers, and reduces their water holding capacity. Flood risk is also influenced by sedimentation

Pest management:
an overuse of chemical in citrus farms can cause

No. 4

Source: www.pentapure.net/images/f03nh.jpg

Source: www.mja.com.au/public/issues/183_11_051205/ng10088_fm-1.jpg

Source: www.epa.qld.gov.au/images/environmental_management/water/fishkill2.jpg

Acute toxicity: When high doses of pesticide reaching a water body over a short period of time, it can cause acute toxicity such as killing fish

Chronic toxicity: Drinking water is contaminated when the exposure occurs over many years at significant concentration

Nutrient management:
an over-application of nutrient in citrus farms can cause

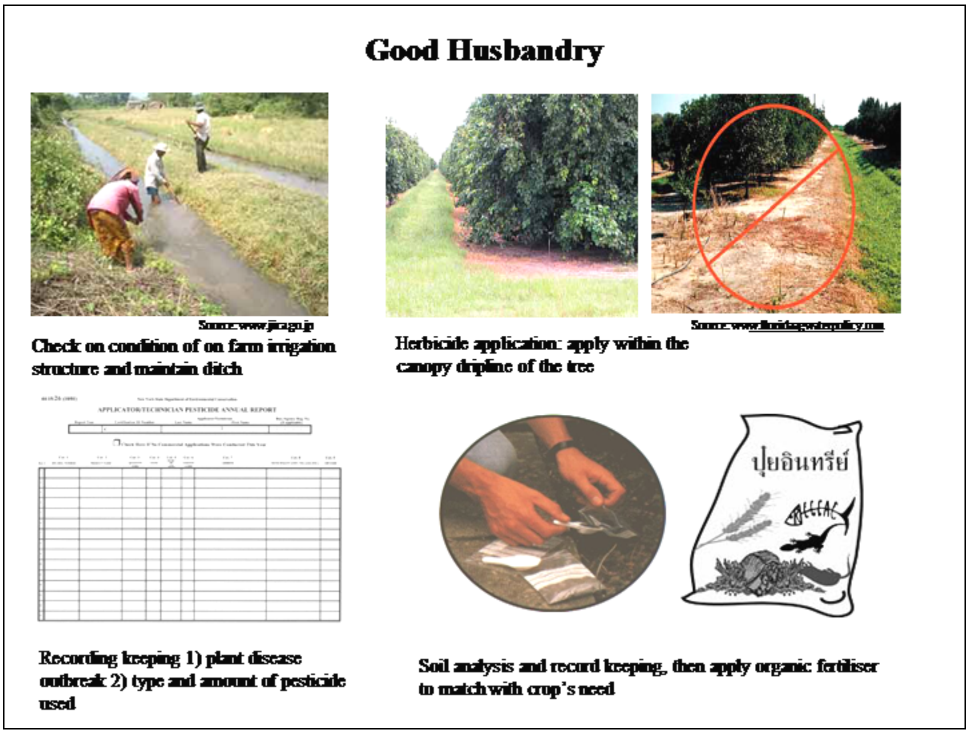
No. 5

Source: www.waterencyclopedia.com/images/wsci_03_img0371.jpg

Eutrophication: Over application of nutrient, such as Nitrogen and Phosphorus, can harm water quality. The eutrophication is caused by enrichment of fertiliser that stimulate the growth of algae and other plankton. An over production of plankton and as they die and decompose, they use up the oxygen which cause other oxygen-dependent organism (e.g. fish) to die.

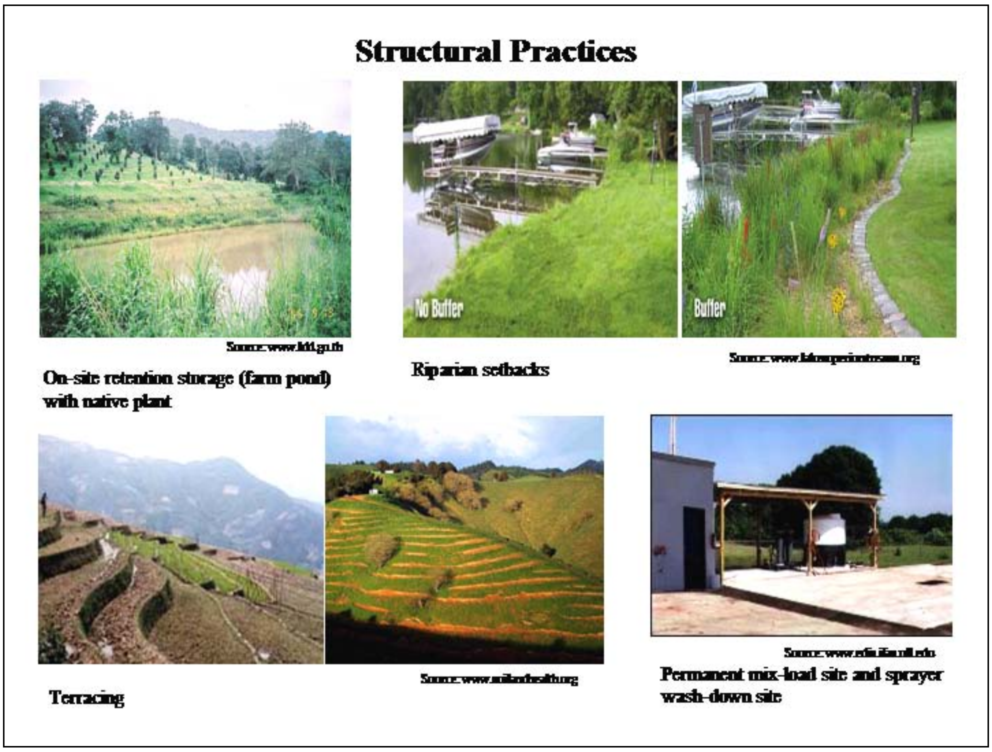
Twelve BMPs by categories

Good Husbandry

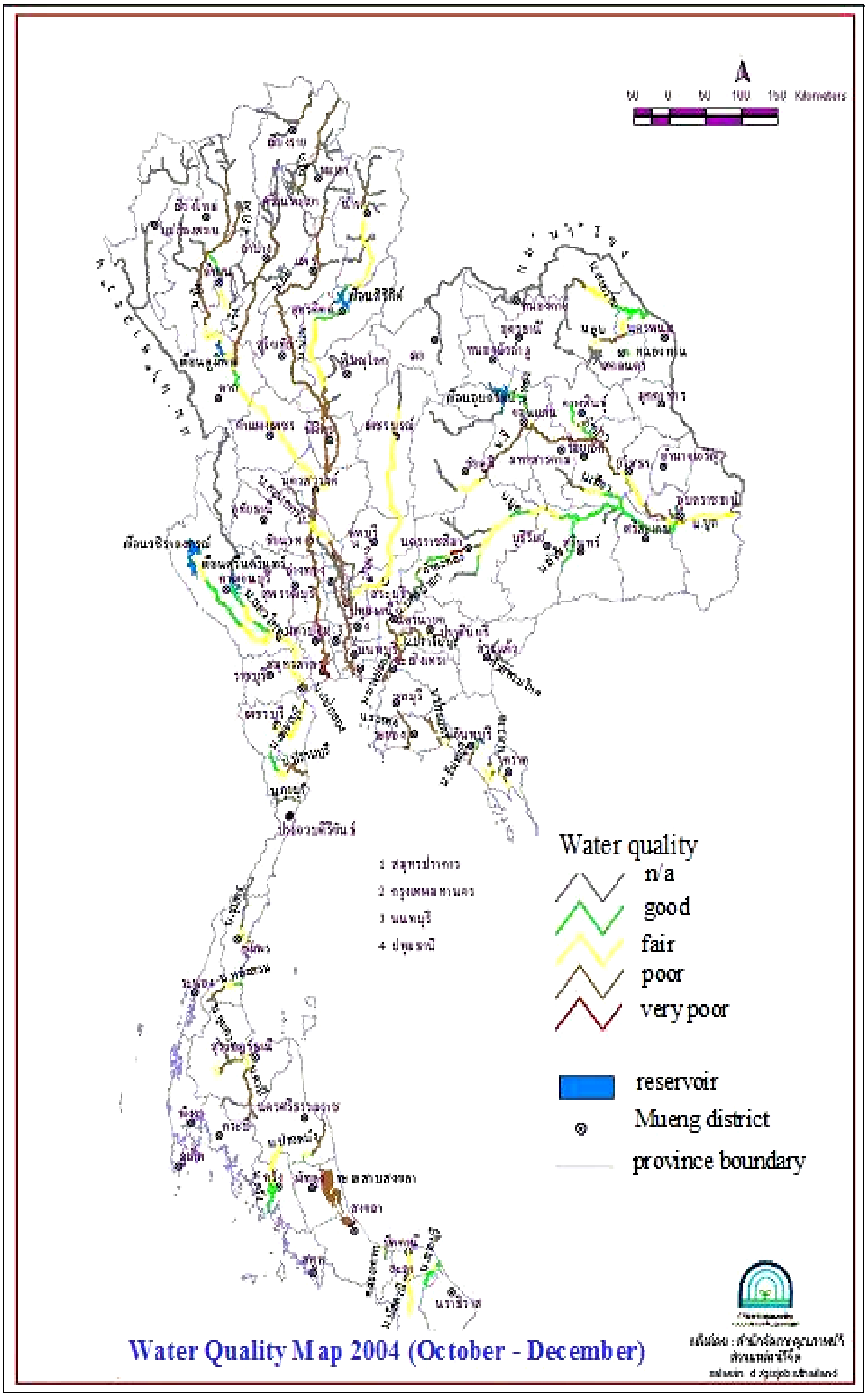


Vegetative Practices

Structural Practices



Water quality map



Annex 7: Forward stepwise methods to select psychological variables (SPSS 16.0)

Nominal Regression

[DataSet1] H:\nan_SPSS\analysis\DUMMY\Dummy new cutpoffpoint.sav

Step Summary

Model		Action	Effect(s)	Model Fitting Criteria			Effect Selection Tests		
				AIC	BIC	-2 Log Likelihood	Chi-Square[a]	df	Sig.
Step 0	0	Entered	Intercept	340.065	346.834	336.065	.		
Step 1	1	Entered	PBC1g3	335.615	349.153	327.615	8.451	2	.015
Step 2	2	Entered	PBC2g2	330.383	350.690	318.383	9.232	2	.010
Step 3	3	Entered	SN1g2	327.587	354.662	311.587	6.796	2	.033
Step 4	4	Entered	SN1g3	321.767	355.612	301.767	9.820	2	.007
	5	Removed	PBC1g3	322.111	349.187	306.111	4.344	2	.114

Stepwise Method: Forward Stepwise

a. The chi-square for entry is based on the likelihood ratio test.

Model Fitting Information

Model	Model Fitting Criteria			Likelihood Ratio Tests		
	AIC	BIC	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	340.065	346.834	336.065			
Final	322.111	349.187	306.111	29.954	6	.000

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	420.348	420	.486
Deviance	301.952	420	1.000

Pseudo R-Square

Cox and Snell	.128
Nagelkerke	.163
McFadden	.088

Likelihood Ratio Tests

Effect	Model Fitting Criteria			Likelihood Ratio Tests		
	AIC of Reduced Model	BIC of Reduced Model	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	322.111	349.187	3.061E2	.000	0	.
PBC2g2	326.574	346.881	314.574	8.463	2	.015
SN1g3	333.586	353.893	321.586	15.475	2	.000
SN1g2	332.114	352.421	320.114	14.003	2	.001

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

Parameter Estimates

Category of the 1st order[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B) Lower Bound	Upper Bound
Vegetative practice	Intercept	.252	1.163	.047	1	.828			
	[PBC2g2=0]	.899	.488	3.400	1	.065	2.457	.945	6.388
	[PBC2g2=1]	0[b]	.	.	0	.	.	.	.
	[SN1g3=0]	-2.700	1.052	6.587	1	.010	.067	.009	.528
	[SN1g3=1]	0[b]	.	.	0	.	.	.	.
	[SN1g2=0]	-2.106	1.091	3.724	1	.054	.122	.014	1.033
	[SN1g2=1]	0[b]	.	.	0	.	.	.	.
Structural practice	Intercept	-3.435	.719	22.841	1	.000			
	[PBC2g2=0]	.975	.422	5.352	1	.021	2.652	1.161	6.060
	[PBC2g2=1]	0[b]	.	.	0	.	.	.	.
	[SN1g3=0]	.372	.408	.830	1	.362	1.451	.652	3.230
	[SN1g3=1]	0[b]	.	.	0	.	.	.	.
	[SN1g2=0]	1.394	.592	5.546	1	.019	4.031	1.263	12.862
	[SN1g2=1]	0[b]	.	.	0	.	.	.	.

a. The reference category is: Good husbandry.

b. This parameter is set to zero because it is redundant.

Classification

Observed	Predicted: Good husbandry	Vegetative practice	Structural practice	Percent Correct
Good husbandry	157	0	0	100.0%
Vegetative practice	24	0	0	.0%
Structural practice	37	0	0	.0%
Overall Percentage	100.0%	.0%	.0%	72.0%

Annex 8: Forced entry method (SPSS 16.0)

Nominal Regression
[DataSet1] H:\nan_SPSS\analysis\DUMMY\Dummy new cutpoffpoint.sav

Model Fitting Information

	Model Fitting Criteria			Likelihood Ratio Tests		
Model	AIC	BIC	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	344.224	350.993	340.224			
Final	340.548	550.387	216.548	123.676	60	.000

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	363.276	374	.645
Deviance	216.548	374	1.000

Pseudo R-Square

Cox and Snell	.433
Nagelkerke	.548
McFadden	.364

Likelihood Ratio Tests

	Model Fitting Criteria			Likelihood Ratio Tests		
Effect	AIC of Reduced Model	BIC of Reduced Model	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	340.548	550.387	2.165E2	.000	0	.
nPRIg3	345.208	548.278	225.208	8.660	2	.013
nPRIg1	340.548	550.387	2.165E2	.000	0	.
nGOVg2	336.813	539.883	216.813	.265	2	.876
MEMg2	337.804	540.873	217.804	1.256	2	.534
DT1	338.270	541.340	218.270	1.723	2	.423
IN1	336.899	539.969	216.899	.351	2	.839
LANDg2	338.344	541.414	218.344	1.796	2	.407
PT1	336.918	539.988	216.918	.370	2	.831
FW1	341.817	544.887	221.817	5.269	2	.072
SOILg3	338.957	542.027	218.957	2.410	2	.300
SOILg1	340.548	550.387	2.165E2	.000	0	.
STREAMg1	340.548	550.387	2.165E2	.000	0	.
UT	340.548	550.387	2.165E2	.000	0	.
SIZEg4	348.499	551.569	228.499	11.951	2	.003
SIZEg2	341.099	544.169	221.099	4.551	2	.103
HEALTHg2	336.808	539.877	216.808	.260	2	.878
PAST1	339.080	542.150	219.080	2.532	2	.282
CROPg2	350.182	553.251	230.182	13.634	2	.001
GENg2	339.745	542.815	219.745	3.197	2	.202
EDU1	340.427	543.497	220.427	3.879	2	.144
AGEg5	338.302	541.371	218.302	1.754	2	.416
AGEg3	337.606	540.676	217.606	1.058	2	.589
AGEg1	340.548	550.387	2.165E2	.000	0	.

SN1g2	356.323	559.393	236.323	19.775	2	.000
PBC2g2	347.231	550.300	227.231	10.683	2	.005
SN1g3	356.507	559.577	236.507	19.959	2	.000
AGEg2	338.198	541.268	218.198	1.650	2	.438
AGEg4	338.102	541.171	218.102	1.554	2	.460
EDUr	340.548	550.387	2.165E2	.000	0	.
GENg1	340.548	550.387	2.165E2	.000	0	.
CROPg1	340.548	550.387	2.165E2	.000	0	.
PASTr	340.548	550.387	2.165E2	.000	0	.
HEALTHg1	340.548	550.387	2.165E2	.000	0	.
SIZEg1	340.548	550.387	2.165E2	.000	0	.
SIZEg3	337.379	540.449	217.379	.831	2	.660
SIZEg5	354.376	557.446	234.376	17.828	2	.000
DT	339.131	542.201	219.131	2.583	2	.275
STREAMg2	337.027	540.097	217.027	.479	2	.787
SOILg2	337.187	540.256	217.187	.639	2	.727
FWr	340.548	550.387	2.165E2	.000	0	.
PTr	340.548	550.387	2.165E2	.000	0	.
LANDg1	340.548	550.387	2.165E2	.000	0	.
INr	340.548	550.387	2.165E2	.000	0	.
DTr	340.548	550.387	2.165E2	.000	0	.
MEMg1	340.548	550.387	2.165E2	.000	0	.
nGOVg1	340.548	550.387	2.165E2	.000	0	.
nGOVg3	336.718	539.788	216.718	.170	2	.918
nPRIg2	344.120	547.190	224.120	7.572	2	.023

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

Parameter Estimates

Category of the 1st order[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B) Lower Bound	Upper Bound
Vegetative practice	Intercept	-23.172	7.831	8.755	1	.003			
	[nPRIg3=0]	20.813	.000	.	1	.	1.094E9	1.094E9	1.094E9
	[nPRIg3=1]	0[b]	.	.	0	.	.	.	.
	[nPRIg1=0]	0[b]	.	.	0	.	.	.	.
	[nGOVg2=0]	.367	.795	.214	1	.644	1.444	.304	6.861
	[nGOVg2=1]	0[b]	.	.	0	.	.	.	.
	[MEMg2=0]	-.169	.785	.046	1	.829	.844	.181	3.935
	[MEMg2=1]	0[b]	.	.	0	.	.	.	.
	[DT1=0]	.078	.750	.011	1	.917	1.081	.248	4.704
	[DT1=1]	0[b]	.	.	0	.	.	.	.
	[IN1=0]	.445	.769	.336	1	.562	1.561	.346	7.040
	[IN1=1]	0[b]	.	.	0	.	.	.	.
	[LANDg2=0]	-.815	.898	.825	1	.364	.443	.076	2.571
	[LANDg2=1]	0[b]	.	.	0	.	.	.	.
	[PT1=0]	.302	1.029	.086	1	.769	1.353	.180	10.165
	[PT1=1]	0[b]	.	.	0	.	.	.	.
	[FW1=0]	2.854	1.421	4.033	1	.045	17.363	1.071	281.476
	[FW1=1]	0[b]	.	.	0	.	.	.	.

	[SOILg3=0]	.956	.756	1.597	1	.206	2.601	.591	11.452
	[SOILg3=1]	0b	.	.	0	.	.	.	.
	[SOILg1=0]	0b	.	.	0	.	.	.	.
	[STREAMg1=0]	0b	.	.	0	.	.	.	.
	[UT=0]	0b	.	.	0	.	.	.	.
	[SIZEg4=0]	2.194	1.389	2.494	1	.114	8.970	.589	136.583
	[SIZEg4=1]	0b	.	.	0	.	.	.	.
	[SIZEg2=0]	1.998	.995	4.028	1	.045	7.373	1.048	51.874
	[SIZEg2=1]	0b	.	.	0	.	.	.	.
	[HEALTHg2=0]	.291	.696	.175	1	.675	1.338	.342	5.231
	[HEALTHg2=1]	0b	.	.	0	.	.	.	.
	[PAST1=0]	.653	1.017	.412	1	.521	1.921	.262	14.102
	[PAST1=1]	0b	.	.	0	.	.	.	.
	[CROPg2=0]	1.118	.729	2.351	1	.125	3.060	.732	12.784
	[CROPg2=1]	0b	.	.	0	.	.	.	.
	[GENg2=0]	.168	.680	.061	1	.805	1.183	.312	4.485
	[GENg2=1]	0b	.	.	0	.	.	.	.
	[EDU1=0]	1.382	.837	2.726	1	.099	3.981	.772	20.523
	[EDU1=1]	0b	.	.	0	.	.	.	.
	[AGEg5=0]	-2.770	2.201	1.584	1	.208	.063	.001	4.680
	[AGEg5=1]	0b	.	.	0	.	.	.	.
	[AGEg3=0]	-2.051	2.068	.984	1	.321	.129	.002	7.401
	[AGEg3=1]	0b	.	.	0	.	.	.	.
	[AGEg1=0]	0b	.	.	0	.	.	.	.
	[SN1g2=0]	-2.774	1.271	4.767	1	.029	.062	.005	.753
	[SN1g2=1]	0b	.	.	0	.	.	.	.
	[PBC2g2=0]	1.651	.731	5.110	1	.024	5.214	1.246	21.827
	[PBC2g2=1]	0b	.	.	0	.	.	.	.
	[SN1g3=0]	-3.625	1.239	8.562	1	.003	.027	.002	.302
	[SN1g3=1]	0b	.	.	0	.	.	.	.
	[AGEg2=0]	-2.061	1.952	1.115	1	.291	.127	.003	5.841
	[AGEg2=1]	0b	.	.	0	.	.	.	.
	[AGEg4=0]	-2.372	2.004	1.400	1	.237	.093	.002	4.744
	[AGEg4=1]	0b	.	.	0	.	.	.	.
	[EDUr=0]	0b	.	.	0	.	.	.	.
	[GENg1=0]	0b	.	.	0	.	.	.	.
	[CROPg1=0]	0b	.	.	0	.	.	.	.
	[PASTr=0]	0b	.	.	0	.	.	.	.
	[HEALTHg1=0]	0b	.	.	0	.	.	.	.
	[SIZEg1=0]	0b	.	.	0	.	.	.	.
	[SIZEg3=0]	.624	1.019	.375	1	.540	1.866	.253	13.755
	[SIZEg3=1]	0b	.	.	0	.	.	.	.
	[SIZEg5=0]	1.137	1.540	.545	1	.460	3.117	.152	63.749
	[SIZEg5=1]	0b	.	.	0	.	.	.	.
	[DT=0]	-.694	1.068	.422	1	.516	.500	.062	4.056
	[DT=1]	0b	.	.	0	.	.	.	.
	[STREAMg2=0]	-.535	.772	.481	1	.488	.586	.129	2.659

	[STREAMg2=1]	0[b]	.	.	0	.	.	.	.
	[SOILg2=0]	.672	1.120	.360	1	.548	1.958	.218	17.574
	[SOILg2=1]	0[b]	.	.	0	.	.	.	.
	[FWr=0]	0[b]	.	.	0	.	.	.	.
	[PTr=0]	0[b]	.	.	0	.	.	.	.
	[LANDg1=0]	0[b]	.	.	0	.	.	.	.
	[INr=0]	0[b]	.	.	0	.	.	.	.
	[DTr=0]	0[b]	.	.	0	.	.	.	.
	[MEMg1=0]	0[b]	.	.	0	.	.	.	.
	[nGOVg1=0]	0[b]	.	.	0	.	.	.	.
	[nGOVg3=0]	-.319	.905	.124	1	.725	.727	.123	4.286
	[nGOVg3=1]	0[b]	.	.	0	.	.	.	.
	[nPRIg2=0]	2.301	1.005	5.236	1	.022	9.980	1.391	71.605
	[nPRIg2=1]	0[b]	.	.	0	.	.	.	.
Structural practice	Intercept	-1.666	5.548	.090	1	.764			
	[nPRIg3=0]	1.556	1.753	.787	1	.375	4.739	.152	147.309
	[nPRIg3=1]	0[b]	.	.	0	.	.	.	.
	[nPRIg1=0]	0[b]	.	.	0	.	.	.	.
	[nGOVg2=0]	-.108	.633	.029	1	.865	.898	.260	3.102
	[nGOVg2=1]	0[b]	.	.	0	.	.	.	.
	[MEMg2=0]	.672	.640	1.104	1	.293	1.959	.559	6.867
	[MEMg2=1]	0[b]	.	.	0	.	.	.	.
	[DT1=0]	.791	.608	1.694	1	.193	2.206	.670	7.265
	[DT1=1]	0[b]	.	.	0	.	.	.	.
	[IN1=0]	-.036	.547	.004	1	.947	.964	.330	2.819
	[IN1=1]	0[b]	.	.	0	.	.	.	.
	[LANDg2=0]	.930	1.078	.744	1	.388	2.533	.307	20.936
	[LANDg2=1]	0[b]	.	.	0	.	.	.	.
	[PT1=0]	-.369	.742	.247	1	.619	.691	.161	2.961
	[PT1=1]	0[b]	.	.	0	.	.	.	.
	[FW1=0]	.882	.872	1.022	1	.312	2.415	.437	13.352
	[FW1=1]	0[b]	.	.	0	.	.	.	.
	[SOILg3=0]	-.515	.710	.527	1	.468	.597	.149	2.401
	[SOILg3=1]	0[b]	.	.	0	.	.	.	.
	[SOILg1=0]	0[b]	.	.	0	.	.	.	.
	[STREAMg1=0]	0[b]	.	.	0	.	.	.	.
	[UT=0]	0[b]	.	.	0	.	.	.	.
	[SIZEg4=0]	-2.451	.942	6.773	1	.009	.086	.014	.546
	[SIZEg4=1]	0[b]	.	.	0	.	.	.	.
	[SIZEg2=0]	-.260	.827	.099	1	.753	.771	.152	3.903
	[SIZEg2=1]	0[b]	.	.	0	.	.	.	.
	[HEALTHg2=0]	.209	.646	.105	1	.746	1.233	.348	4.371
	[HEALTHg2=1]	0[b]	.	.	0	.	.	.	.
	[PAST1=0]	-.816	.606	1.818	1	.178	.442	.135	1.448
	[PAST1=1]	0[b]	.	.	0	.	.	.	.
	[CROPg2=0]	2.308	.789	8.556	1	.003	10.056	2.142	47.223
	[CROPg2=1]	0[b]	.	.	0	.	.	.	.
	[GENg2=0]	-1.068	.620	2.971	1	.085	.344	.102	1.158
	[GENg2=1]	0[b]	.	.	0	.	.	.	.

	[EDU1=0]	-.355	.561	.399	1	.527	.701	.233	2.107
	[EDU1=1]	0[b]	.	.	0	.	.	.	.
	[AGEg5=0]	-.193	1.093	.031	1	.860	.824	.097	7.028
	[AGEg5=1]	0[b]	.	.	0	.	.	.	.
	[AGEg3=0]	-.178	1.053	.028	1	.866	.837	.106	6.590
	[AGEg3=1]	0[b]	.	.	0	.	.	.	.
	[AGEg1=0]	0[b]	.	.	0	.	.	.	.
	[SN1g2=0]	2.277	.782	8.473	1	.004	9.752	2.104	45.190
	[SN1g2=1]	0[b]	.	.	0	.	.	.	.
	[PBC2g2=0]	1.318	.584	5.101	1	.024	3.736	1.190	11.724
	[PBC2g2=1]	0[b]	.	.	0	.	.	.	.
	[SN1g3=0]	.877	.638	1.887	1	.170	2.404	.688	8.402
	[SN1g3=1]	0[b]	.	.	0	.	.	.	.
	[AGEg2=0]	-.828	1.043	.631	1	.427	.437	.057	3.373
	[AGEg2=1]	0[b]	.	.	0	.	.	.	.
	[AGEg4=0]	-.206	1.086	.036	1	.849	.814	.097	6.835
	[AGEg4=1]	0[b]	.	.	0	.	.	.	.
	[EDUr=0]	0[b]	.	.	0	.	.	.	.
	[GENg1=0]	0[b]	.	.	0	.	.	.	.
	[CROPg1=0]	0[b]	.	.	0	.	.	.	.
	[PASTr=0]	0[b]	.	.	0	.	.	.	.
	[HEALTHg1=0]	0[b]	.	.	0	.	.	.	.
	[SIZEg1=0]	0[b]	.	.	0	.	.	.	.
	[SIZEg3=0]	-.570	.931	.375	1	.540	.565	.091	3.506
	[SIZEg3=1]	0[b]	.	.	0	.	.	.	.
	[SIZEg5=0]	-4.108	1.164	12.459	1	.000	.016	.002	.161
	[SIZEg5=1]	0[b]	.	.	0	.	.	.	.
	[DT=0]	1.016	.750	1.836	1	.175	2.763	.635	12.018
	[DT=1]	0[b]	.	.	0	.	.	.	.
	[STREAMg2=0]	-.058	.590	.010	1	.922	.944	.297	2.998
	[STREAMg2=1]	0[b]	.	.	0	.	.	.	.
	[SOILg2=0]	-.398	.866	.211	1	.646	.672	.123	3.666
	[SOILg2=1]	0[b]	.	.	0	.	.	.	.
	[FWr=0]	0[b]	.	.	0	.	.	.	.
	[PTr=0]	0[b]	.	.	0	.	.	.	.
	[LANDg1=0]	0[b]	.	.	0	.	.	.	.
	[INr=0]	0[b]	.	.	0	.	.	.	.
	[DTr=0]	0[b]	.	.	0	.	.	.	.
	[MEMg1=0]	0[b]	.	.	0	.	.	.	.
	[nGOVg1=0]	0[b]	.	.	0	.	.	.	.
	[nGOVg3=0]	-.205	.791	.067	1	.796	.815	.173	3.837
	[nGOVg3=1]	0[b]	.	.	0	.	.	.	.
	[nPRIg2=0]	1.392	.765	3.309	1	.069	4.023	.898	18.032
	[nPRIg2=1]	0[b]	.	.	0	.	.	.	.

a. The reference category is: Good husbandry.

b. This parameter is set to zero because it is redundant.

Classification

Observed	Predicted			
	Good husbandry	Vegetative practice	Structural practice	Percent Correct
Good husbandry	145	5	7	92.4%
Vegetative practice	14	8	2	33.3%
Structural practice	19	1	17	45.9%
Overall Percentage	81.7%	6.4%	11.9%	78.0%

Annex 9: Q-Sample

	Social aspect		Ecological aspect		Economic aspect	
Water resource management	Our water here is as safe to drink as anywhere in the country (1)	I can no longer fish from river that used to be a food source for a decade (4)	I have never discharged waste into natural watercourses (2)	Natural watercourses are contaminated with chemicals (5)	Good water quality is a social benefit (3)	If I adopt BMPs, the natural watercourse will be cleaner and water can be re-used for planting other crops (6)
Erosion control and sediment management	Government agencies should provide advisory services on soil management (7)	I do not know which tree could reduce soil erosion effects (10)	To control weeds and grass, I prefer to use a power lawnmower than herbicides (8)	Soil on my farm is easily eroded (11)	Vetiver (local plant) can stabilise farm ditches, but I cannot afford to buy the plants (9)	I do not have enough land to allocate to BMP activities (12)
Pest management	Chemically sprayed citrus from my farm is safe to eat (13)	Applying the dosage of chemicals suggested on the label will not harm human health (16)	We should use organic substances instead of chemical pesticides on citrus farms (14)	Chemicals do not always imply toxicity (17)	If I do not apply pesticide as I have been accustomed to do, the fruit quality may drop (15)	Chemical-free labels on food are important for consumer purchasing decisions (18)
Nutrient management	I tend to use fertilisers that are widely used by my neighbours (19)	I am happy to use fertilisers introduced by agricultural input retailers (22)	An application of organic fertiliser rather than chemicals will reduce pollution (20)	Growers should apply the right amount of fertiliser to match the trees' need because over-application will harm the environment (23)	The application of organic fertiliser will give better fruit quality (21)	Without an application of chemical fertiliser, trees do not provide good yield (24)
Overall views about BMPs	BMPs are needed to stop fighting between citrus growers and residents (25)	My neighbours will support me if I adopt BMPs (28)	Man cause pollutant emission, therefore we should take some actions to lessen pollution (26)	We can gain more watershed benefits if we can restrict pollution from our farm production (29)	Growers can comply with BMPs if they get enough monetary support from government (27)	In the long run, BMPs help enhance competitiveness in terms of chemical-free product (30)
	The BMPs will lead to more red-tape, but I can adopt them despite this (31)	We could not introduce BMPs correctly because we do not have enough understanding (34)	We should restrict citrus cultivation to designated areas (32)	Most citrus growers are not aware of water availability in the watershed (35)	Labour requirement for BMPs is a big problem (33)	I cannot adopt BMPs because I do not have enough funds (36)

Note: Number in parenthesis indicates statement number

Annex 10: Results from PQMTHOD

Loadings

PQMethod2.11 72 samples
PAGE 11
Path and Project Name: C:\PQMETHOD\PROJECTS/newping
Aug 29 08

Factor Matrix with an X Indicating a Defining Sort

		Loadings			
QSORT		1	2	3	4
1	CM1	0.3062	-0.0586	0.4928X	0.2276
2	CM2	0.3420	0.1158	0.0163	0.5009X
3	CM3	0.2720	0.2319	-0.0365	0.5737X
4	CM4	0.6053X	0.1591	0.2339	0.4061
5	CM5	0.3581	0.1662	0.3165	0.5553X
6	CM6	0.0518	0.4431	0.2401	0.4541X
7	CM7	0.4593X	0.1195	0.2959	0.1761
8	CM8	0.4587X	0.1033	0.4185	0.0549
9	CM9	0.2984	0.5869X	0.0974	0.4776
10	CM10	0.3189	0.2283	-0.2594	0.1641
11	CM11	0.1889	0.4872X	0.3512	0.4761
12	CM12	0.1010	0.0798	0.4583	0.5997X
13	CM13	0.1282	0.4199	0.3013	0.6045X
14	CM14	-0.1757	0.1263	0.3144	0.7014X
15	CM15	0.3877	0.0093	-0.0148	0.5801X
16	CM16	0.5869X	0.2663	0.0605	0.3292
17	CM17	0.2451	0.1225	0.3338	0.2391
18	CM18	0.3076	0.3391	0.0429	0.6311X
19	KP19	0.6342X	-0.2676	0.2283	0.2641
20	KP20	0.2431	0.4904X	0.4316	0.4499
21	KP21	0.1530	-0.0369	0.5194X	-0.5805
22	KP22	0.3969	0.3417	0.4252X	0.0776
23	KP23	0.7164X	0.1396	0.2560	0.0388
24	KP24	0.0069	0.2166	0.7126X	-0.0891
25	KP25	-0.1192	0.1552	0.7456X	0.0899
26	KP26	0.3101	0.5841X	0.1290	0.3767
27	KP27	0.4347X	0.2724	0.3655	0.3291
28	KP28	0.1312	0.3024	0.4866X	0.2403
29	KP29	0.2228	0.7924X	0.0423	0.1017
30	KP30	0.0682	0.7325X	0.0854	0.0942
31	KP31	0.1554	0.2564	0.4869X	0.0520
32	KP32	0.6241X	0.1090	0.5272	0.0257
33	KP33	0.6669X	0.3166	-0.2797	-0.0630
34	KP34	0.5929X	0.2602	0.1479	0.0575
35	NK35	0.3370	0.1090	0.2796	0.1668
36	NK36	0.4688	0.4789X	0.1172	0.3132
37	NK37	0.2758	0.5042X	0.3430	0.3957
38	NK38	0.3882	0.5174X	0.4586	0.3208
39	NK39	0.2942	0.0128	0.5179X	0.3233
40	NK40	-0.1210	0.2707	-0.4654	-0.1447
41	NK41	0.3915	0.5713X	0.4156	0.0187
42	KP42	0.6230X	-0.0106	0.3169	0.3448

PQMethod2.11 72 samples
PAGE 12
Path and Project Name: C:\PQMETHOD\PROJECTS/newping
Aug 29 08

Factor Matrix with an X Indicating a Defining Sort (continued)

Loadings

QSORT	1	2	3	4
43 CM43	0.0864	0.3790	-0.1313	0.4471X
44 CM44	0.4063X	0.2499	0.1270	-0.0722
45 CM45	-0.1409	0.2426	0.2515	0.5246X
46 CM46	0.2899	0.5153X	0.2576	0.1850
47 CM47	0.4584	0.4911X	0.2444	0.4763
48 CM48	0.0480	0.1179	0.5138X	0.2669
49 CM49	-0.1484	0.4240X	0.2156	0.0345
50 CM50	0.4652X	0.0046	0.3490	0.4045
51 CM51	-0.4102	0.2238	0.0460	0.2916
52 CM52	-0.0664	0.4293	0.4679X	0.3214
53 MHS53	0.3639X	0.0492	0.0565	0.3095
54 MHS54	0.0798	0.2172	0.1272	0.7485X
55 MHS55	0.0716	0.4552X	0.0889	0.4391
56 MHS56	0.2868	0.1305	0.4876X	-0.0548
57 MHS57	0.3047	0.0838	0.2234	0.4908X
58 MHS58	0.2148	-0.1037	0.4907X	0.4345
59 MHS59	0.2031	-0.1433	0.2505	0.5759X
60 KP60	0.1186	0.1746	0.4751X	0.2126
61 KP61	0.3036	0.1417	-0.0528	0.2311
62 KP62	0.2379	-0.0860	0.3219	0.4087X
63 KP63	0.3152	0.0102	0.5931X	0.3049
64 KP64	0.1257	-0.0351	0.2542	0.6253X
65 KP65	0.2923	0.4256X	0.3645	0.2424
66 KP66	0.3152	0.2798	0.2819	0.3934
67 KP67	-0.0467	0.5573X	0.0169	-0.1016
68 KP68	0.0006	0.2946	0.6220X	0.1901
69 KP69	0.0405	0.1482	0.5178X	0.4085
70 KP70	0.1003	0.0800	0.1540	0.4401X
71 LP71	0.3562	0.2908	0.4488X	0.1409
72 LP72	0.7646X	-0.1738	0.0927	0.3398
% expl.Var.	12	10	12	14

Distinguishing statements

PQMethod2.11 72 samples PAGE
30
Path and Project Name: C:\PQMETHOD\PROJECTS/newping Aug 29
08

Distinguishing Statements for Factor 1

(P < .05; Asterisk (*) Indicates Significance at P < .01)

Both the Factor Q-Sort Value and the Normalized Score are shown.

No.	Statement	No.	Factor 1 RNK	Factor 1 SCORE	Factor 2 RNK	Factor 2 SCORE	Factor 3 RNK	Factor 3 SCORE	Factor 4 RNK	Factor 4 SCORE
18	Label is importance for buying decision	18	2	1.17	1	0.60	1	0.81	0	0.34
20	Applying of organic fertiliser reduces pollution	20	2	1.01	1	0.60	3	1.38	1	0.64
26	Letting thing takes care doesn't mean pollution	26	2	0.91*	0	0.05	0	0.14	0	0.22
29	More watershed benefit will be gained	29	1	0.67	0	0.26	0	-0.20	3	1.20
2	I've never discharged waste into watercourse	2	1	0.61*	4	2.16	-1	-0.33	4	1.85
21	Organic fertiliser use give better fruit quality	21	0	0.52	-1	-0.33	2	0.96	0	0.14
9	Though vetiver stabilise hedge, I can't afford	9	0	0.49	2	0.95	0	-0.18	-2	-1.19
28	Neighbours will support if I adopt	28	0	0.35	0	-0.21	1	0.84	1	0.74
4	I can't fish from lake used to be food source	4	0	0.21*	-2	-1.02	-1	-0.49	-2	-1.49
5	Watercourse is contaminated with chemicals	5	0	0.10*	-3	-1.27	-3	-1.56	-1	-0.61
35	Most of us aren't aware of water quantity	35	-1	-0.50	-1	-0.91	-4	-1.74	-2	-0.92
33	Labour requirement is a big deal	33	-1	-0.57	-2	-0.94	-3	-1.51	0	0.02
11	Soil in my farm is easily eroded	11	-1	-0.65*	-3	-1.11	-2	-1.35	-3	-1.58
13	Sprayed fruit is not dangerous to consume	13	-2	-1.09*	1	0.68	2	0.97	2	1.00
24	W/O chemical fertiliser, citrus can't boost crop	24	-2	-1.22*	0	-0.09	0	0.09	1	0.38
16	Apply suggested dosage won't harm human health	16	-3	-1.34*	1	0.40	0	-0.20	1	0.43
15	If not use pesticide as I did, fruit quality drop	15	-3	-1.56*	2	1.04	1	0.28	0	0.16

Distinguishing Statements for Factor 2

(P < .05 ; Asterisk (*) Indicates Significance at P < .01)

Both the Factor Q-Sort Value and the Normalized Score are shown.

			Factors							
			1		2		3		4	
No.	Statement	No.	RNK	SCORE	RNK	SCORE	RNK	SCORE	RNK	SCORE
15	If not use pesticide as I did, fruit quality drop	15	-3	-1.56	2	1.04*	1	0.28	0	0.16
9	Though vetiver stabilise hedge, I can't afford	9	0	0.49	2	0.95	0	-0.18	-2	-1.19
29	More watershed benefit will be gained	29	1	0.67	0	0.26	0	-0.20	3	1.20
10	I don't know which tree protect soil erosion	10	-1	-0.64	0	-0.01*	-1	-0.71	-3	-1.63
28	Neighbours will support if I adopt	28	0	0.35	0	-0.21*	1	0.84	1	0.74
21	Organic fertiliser use give better fruit quality	21	0	0.52	-1	-0.33*	2	0.96	0	0.14
23	Put right amount of fertiliser	23	1	0.86	-1	-0.37*	1	0.88	2	0.90
30	BMP enhance food safety competitiveness in LR	30	1	0.52	-1	-0.55*	0	0.13	2	0.78
33	Labour requirement is a big deal	33	-1	-0.57	-2	-0.94	-3	-1.51	0	0.02
4	I can't fish from lake used to be food source	4	0	0.21	-2	-1.02*	-1	-0.49	-2	-1.49
31	BMP brings red tape, but I can adopt	31	0	-0.28	-3	-1.09*	-1	-0.28	0	0.06
1	Water is as safe to drink as anywhere	1	-4	-1.97	-4	-2.44	0	-0.23	-4	-2.04

Distinguishing Statements for Factor 3

(P < .05 ; Asterisk (*) Indicates Significance at P < .01)

Both the Factor Q-Sort Value and the Normalized Score are shown.

			Factors							
			1		2		3		4	
No.	Statement	No.	RNK	SCORE	RNK	SCORE	RNK	SCORE	RNK	SCORE
27	We can comply if got monetary support	27	1	0.55	1	0.39	4	2.01*	2	1.04
20	Applying of organic fertiliser reduces pollution	20	2	1.01	1	0.60	3	1.38	1	0.64
3	Good water quality is a social benefit	3	4	1.98	3	1.90	3	1.26*	3	1.77
21	Organic fertiliser use give better fruit quality	21	0	0.52	-1	-0.33	2	0.96	0	0.14
30	BMP enhance food safety competitiveness in LR	30	1	0.52	-1	-0.55	0	0.13	2	0.78
12	I don't have enough land	12	-1	-0.53	-1	-0.64	0	-0.11	-2	-1.26
9	Though vetiver stabilise hedge, I can't afford	9	0	0.49	2	0.95	0	-0.18*	-2	-1.19
16	Apply suggested dosage won't harm human health	16	-3	-1.34	1	0.40	0	-0.20*	1	0.43
29	More watershed benefit will be gained	29	1	0.67	0	0.26	0	-0.20*	3	1.20
1	Water is as safe to drink as anywhere	1	-4	-1.97	-4	-2.44	0	-0.23*	-4	-2.04
2	I've never discharged waste into watercourse	2	1	0.61	4	2.16	-1	-0.33*	4	1.85
4	I can't fish from lake used to be food source	4	0	0.21	-2	-1.02	-1	-0.49*	-2	-1.49
36	Can't adopt because of no fund	36	0	-0.30	0	-0.26	-2	-1.18*	-1	-0.15
32	Cultivation are should be restricted	32	0	-0.04	0	-0.20	-3	-1.49*	-1	-0.30
33	Labour requirement is a big deal	33	-1	-0.57	-2	-0.94	-3	-1.51*	0	0.02
35	Most of us aren't aware of water quantity	35	-1	-0.50	-1	-0.91	-4	-1.74*	-2	-0.92

Distinguishing Statements for Factor 4

(P < .05 ; Asterisk (*) Indicates Significance at P < .01)

Both the Factor Q-Sort Value and the Normalized Score are shown.

			Factors							
			1		2		3		4	
No.	Statement	No.	RNK	SCORE	RNK	SCORE	RNK	SCORE	RNK	SCORE
29	More watershed benefit will be gained	29	1	0.67	0	0.26	0	-0.20	3	1.20*
27	We can comply if got monetary support	27	1	0.55	1	0.39	4	2.01	2	1.04*
8	I prefer power lawnmower to herbicide	8	3	1.39	2	1.20	2	1.22	1	0.53*
17	Chemicals don't always imply toxicity	17	-1	-0.75	-2	-0.93	-1	-0.57	0	0.24*
21	Organic fertiliser use give better fruit quality	21	0	0.52	-1	-0.33	2	0.96	0	0.14
33	Labour requirement is a big deal	33	-1	-0.57	-2	-0.94	-3	-1.51	0	0.02*
14	We should use organic substance	14	2	1.05	2	0.96	2	1.23	-1	-0.16*
34	Not in correct way because of low understanding	34	-2	-1.16	-2	-1.00	-2	-1.17	-1	-0.57
5	Watercourse is contaminated with chemicals	5	0	0.10	-3	-1.27	-3	-1.56	-1	-0.61*
9	Though vetiver stabilise hedge, I can't afford	9	0	0.49	2	0.95	0	-0.18	-2	-1.19*
12	I don't have enough land	12	-1	-0.53	-1	-0.64	0	-0.11	-2	-1.26*
4	I can't fish from lake used to be food source	4	0	0.21	-2	-1.02	-1	-0.49	-2	-1.49*
10	I don't know which tree protect soil erosion	10	-1	-0.64	0	-0.01	-1	-0.71	-3	-1.63*

Consensus statement

PQMethod2.11 72 samples PAGE
34
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08

Consensus Statements -- Those That Do Not Distinguish Between ANY Pair of Factors.

All Listed Statements are Non-Significant at P>.01, and Those Flagged With an * are also Non-Significant at P>.05.

			Factors							
			1		2		3		4	
No.	Statement	No.	RNK	SCORE	RNK	SCORE	RNK	SCORE	RNK	SCORE
6	If I adopt, water is cleaner and reused	6	3	1.27	3	1.52	3	1.59	3	1.19

QANALYZE was completed at 12:01:16

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